Pump Test Report

NGK Metals Corporation RCRA Corrective Measures Implementation

Prepared for:

NGK Metals Corporation P.O. Box 13367 Reading, PA 19612-3367

Prepared by:

RUST Environment & Infrastructure Mechanicsburg, Pennsylvania

May, 1994

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NGK Metals Corporation

Tuckerton Road P.O. Box 13367 Reading, PA 19612-3367 610 921-5000 Fax 610 921-5358

May 13, 1994

CERTIFIED MAIL/RETURN RECEIPT

Mr. Vernon Butler, RPM Corrective Action RCRA Enforcement Section U.S. Environmental Protection Agency Region III 841 Chestnut Building Philadelphia, PA 19107

Re: Initial Administrative Order EPA Docket No. RCRA-III-01-CA Pump Test Report

Dear Mr. Butler:

In accordance with the above referenced Administrative Order and your letter dated April 12, 1994 granting a 30 day extension, enclosed are four (4) copies of the Pump Test Report dated May 13, 1994 completed by RUST Environment & Infrastructure.

I certify that the information contained in or accompanying this letter is true, accurate, and complete. As to the portion of this submission for which I cannot personally verify its accuracy, I certify under penalty of law that this submission and all attachments were prepared in accordance with the procedures designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, or the immediate supervisor of such person(s), the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment for knowing violations.

Sincerely,

NGK METALS CORPORATION

Lynne Woodside

Supervisor, Environmental Affairs

nune Woodside

cc: Mr. Frank Thomas

Mr. Charles Suenkonis





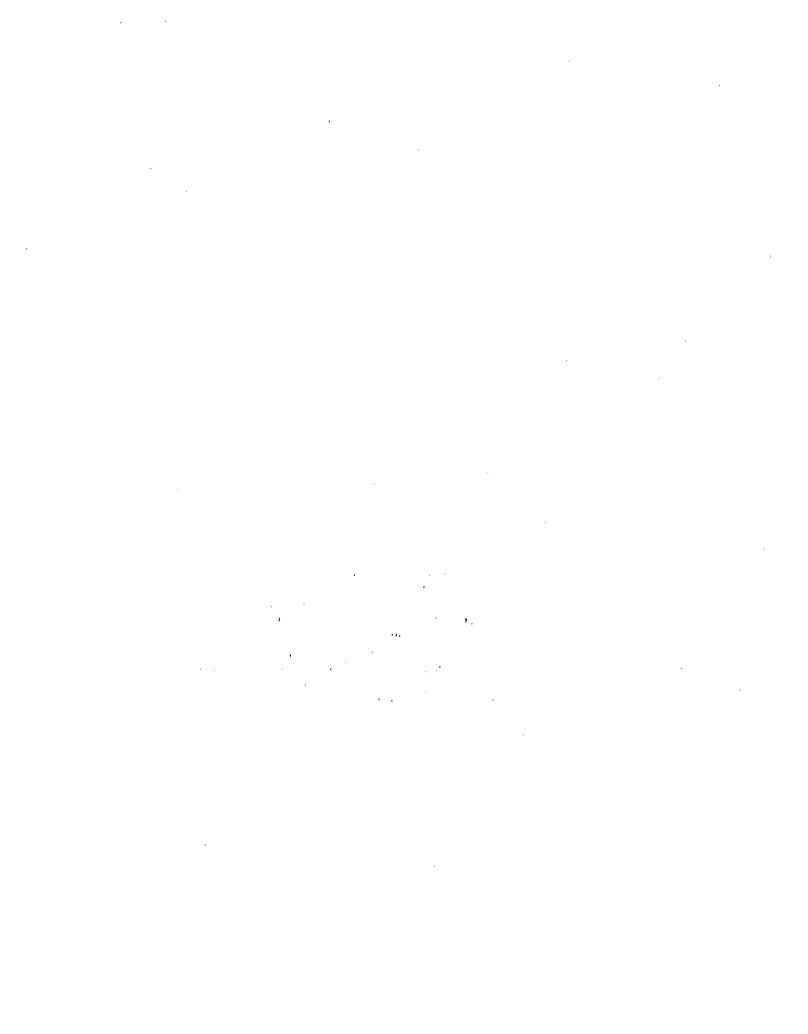


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1.0 EXECUTIVE SUMMARY

Between June 1993 and March, 1994, Rust Environment and Infrastructure (RUST) supervised the installation and construction of seven (7) new on-site monitor wells along with the completion of seven (7) drawdown/recovery tests. The new wells were installed, and drawdown/recovery tests performed to provide additional information in two primary locations of the site (the northeastern and west-southwestern corners), where hydraulic containment is necessary based on previous investigations. These activities were completed at the NGK Metals Corporation (NGK) facility in Reading, Pennsylvania as part of an EPA RCRA Facilities Investigation (RFI). The work was developed and performed in accordance with requirements established in the RCRA Record of Decision (ROD), and the Scope of Work for the Corrective Measures Implementation (CMI) Program.

Five (5) of the new wells were installed in the northeastern section of the site, and the remaining two (2) wells were installed along the western site boundary, for potential use as groundwater withdrawal wells. The location and design of each new well was based on the following information generated during previous site investigations:

- identified contaminant source areas;
- known groundwater flow directions;
- confirmed groundwater chemistry characteristics;
- aquifer characteristics determined by pump test results of three pre-existing monitor wells;
 and
- evaluation of the hydraulic behavior of aquifer materials proximal to and beneath the site through the use of a groundwater model.

Four (4) of the newly installed wells (DW-27, DW-28, DW-29 and DW-32) were pump tested, based on estimated yields of greater than five (5) gallons per minute (gpm) and location. Additionally, three (3) pre-existing wells located near the southwestern corner of the site (SW-8, DW-12 and DW-13) were pump tested and monitored along with selected observation wells for water level responses. The optimal flow rate at each of the pumped wells was determined by preliminary step-drawdown tests that preceded each of the pump tests. Each of the individual pump drawdown tests continued for a minimum of approximately 72 hours. The pump drawdown tests were of sufficient duration to result in measurable drawdown in monitor wells near the respective pumping well.

An evaluation of all drawdown testing completed to date is presented in Section 3 of this report. This evaluation, coupled with existing information, provides the basis for the preliminary design of the groundwater hydraulic containment system for the northeastern and southwestern portions

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of the site, where hydraulic containment is necessary. Test results indicate that, initially, a groundwater hydraulic containment system consisting of wells DW-27 and DW-29 in the northeastern portion of the site along with wells DW-12 and DW-32 in the southwestern corner of the site would be effective in capturing groundwater that has been adversely impacted by previous industrial activities, and preventing the off-site migration of this groundwater.

Along the northeastern perimeter of the site, wells DW-27 and DW-29 will be sufficient to create drawdown zones (i.e. areas of capture) necessary to prevent off-site migration of groundwater. Pump test data suggest that the cumulative effect of pumping these wells will be overlapping cones of depression. Although groundwater chemical data suggest that overlapping cones of depression may not be necessary. Based on pump test data, it is estimated that a total groundwater withdrawal rate from wells DW-27 and DW-29 of about 100 to 130 gallons per minute will be needed to prevent migration of affected groundwater in the northern portion of the site.

Hydraulic containment is achievable along the southwestern perimeter of the site by pumping a combination of wells DW-12 and DW-32 with the possibility of later adding well SW-8. As an alternative, data also suggest that hydraulic containment will be achieved along the southwestern perimeter of the site by pumping a combination of wells DW-12 and DW-32 in conjunction with injection to wells DW-8 and DW-13. Actual pump test data collected from wells DW-12 and DW-32 suggest that overlapping cones of depression may develop after longer term pumping allows the groundwater system to fully achieve equilibrium. Development and maturation of the overlapping cones of depression will be enhanced by the installation of the remedial RCRA caps over the various past disposal areas. The resulting overlapping cones of depression would create a capture zone up to as much as 1000 to 1200 feet in length if pumped simultaneously (through the axis of pumping wells DW-12 and 32). Therefore, it is believed that the total groundwater withdrawal rate from the two wells would be about 150 gallons per minute. If, after long term pumping, the cones of depression do not overlap, then well SW-8 may need to be added to the hydraulic containment system either as a pumping well or injection well. However, if it is determined that well SW-8 needs to be added to the system, total withdrawal from wells DW-12 and 32 would likely be reduced to offset the increase if SW-8 is pumped.

The areas of influence (areas of capture) created by the pumping of these four wells will result in effective capture and containment of contaminated groundwater across the NGK site. The areas of influence, located across the northeastern and southeastern portions of the site are hydraulically downgradient of source areas. These areas of influence will intercept flow from principal areas exhibiting affected groundwater. Subsequent to the installation of the RCRA remedial caps and the hydraulic containment system, final groundwater configurations will change. As a result, the final configuration of the hydraulic containment system may need to be modified (addition or removal of extraction wells) to maximize effectiveness and provide an efficient hydraulic containment system.

A major factor affecting the final selection of the withdrawal wells is the potential limitations regarding final total discharge flow rates of treated groundwater. Treatment and disposal of the

groundwater is a major concern due to discharge limitations at Laurel Run. Therefore, it is imperative that the selected well achieve effective hydraulic containment (i.e. extensive areas of capture) using minimum withdrawal rates.

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2.0 INTRODUCTION

RUST (formerly DUNN) has prepared several reports associated with the NGK Metals Corporation RFI. The principal documents that present details of the site-specific geology, hydrogeology and groundwater chemistry include:

- 1) NGK Metals Corporation, RCRA Facility Investigation (Volumes I and II), Document No. 05756-5, November 15, 1990;
- 2) NGK Metals Corporation, RCRA Facility Investigation Addendum, Document No.5756-8, October 25, 1991; and
- 3) RCRA Corrective Measures Study, Three Dimensional Finite-Difference Groundwater Flow Model, NGK Metals Corporation Reading Facility, February 21, 1992.

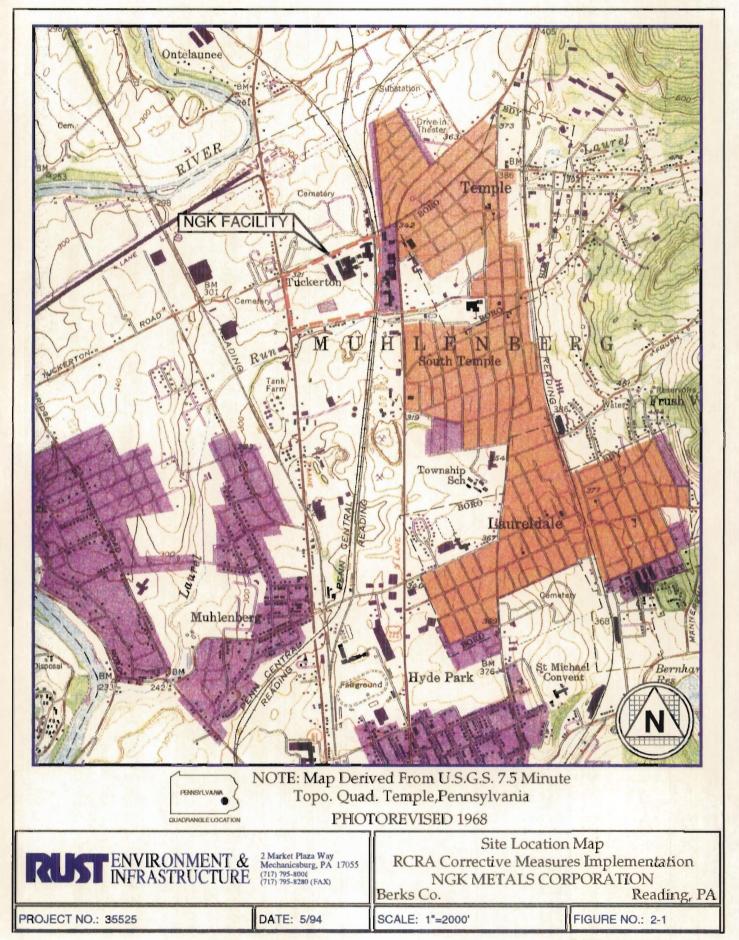
The general information presented in this section of this Pump Test Report has been discussed in greater detail in these and other reports previously generated. The information presented herein serves only as a cursory review of material compiled from these reports, and compliments data acquired during the period from June 1993 to the present. More complete descriptions of the material contained within this section can be found in the reports listed above. Specific information is presented in this report as necessary.

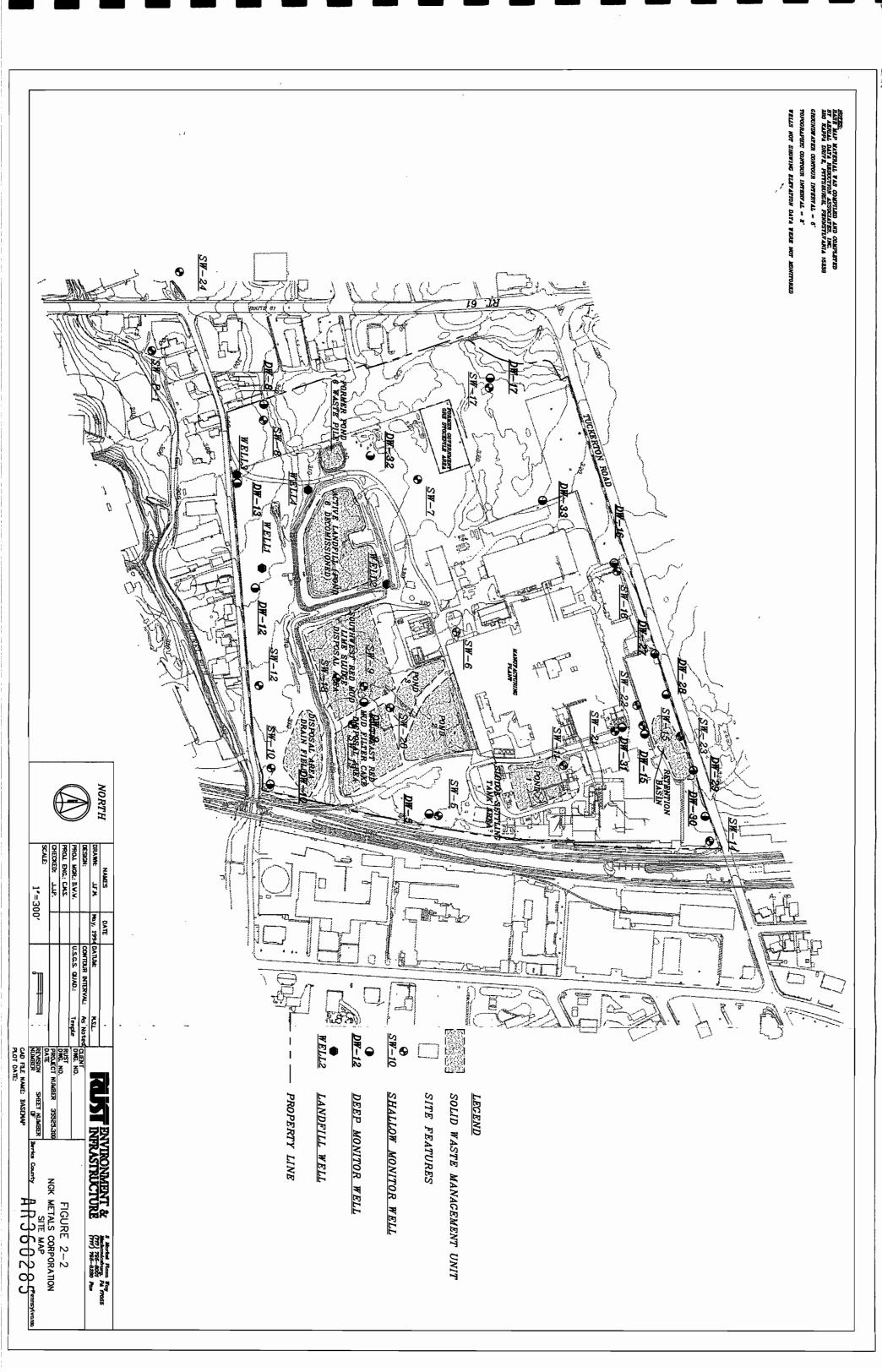
2.1 GEOLOGY

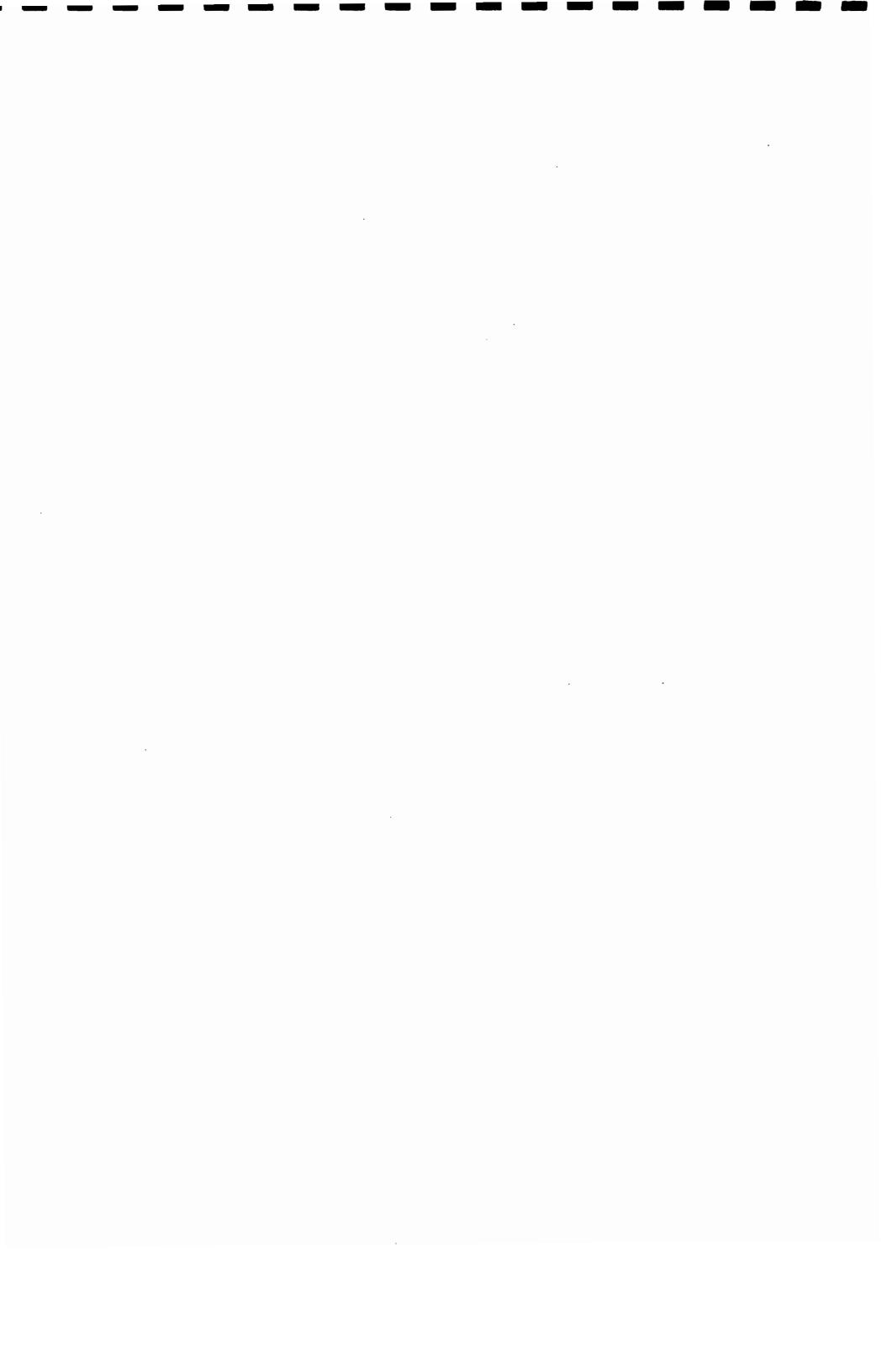
The NGK site, shown on Figures 2-1 and 2-2 consists of two types of unconsolidated material overlying bedrock. One type is a variable thickness, heterogeneous mixture of clay, sand, gravel and boulders. This overburden type is prevalent in the southern half of the site, and varies in thickness from approximately 20 feet to more than 60 feet. The second type of overburden is an orangish-brown residual clay, which formed from the weathering of the parent bedrock below. This clayey overburden is more commonly associated with the northern half of the site, and ranges from about 3 feet to more than 50 feet in thickness.

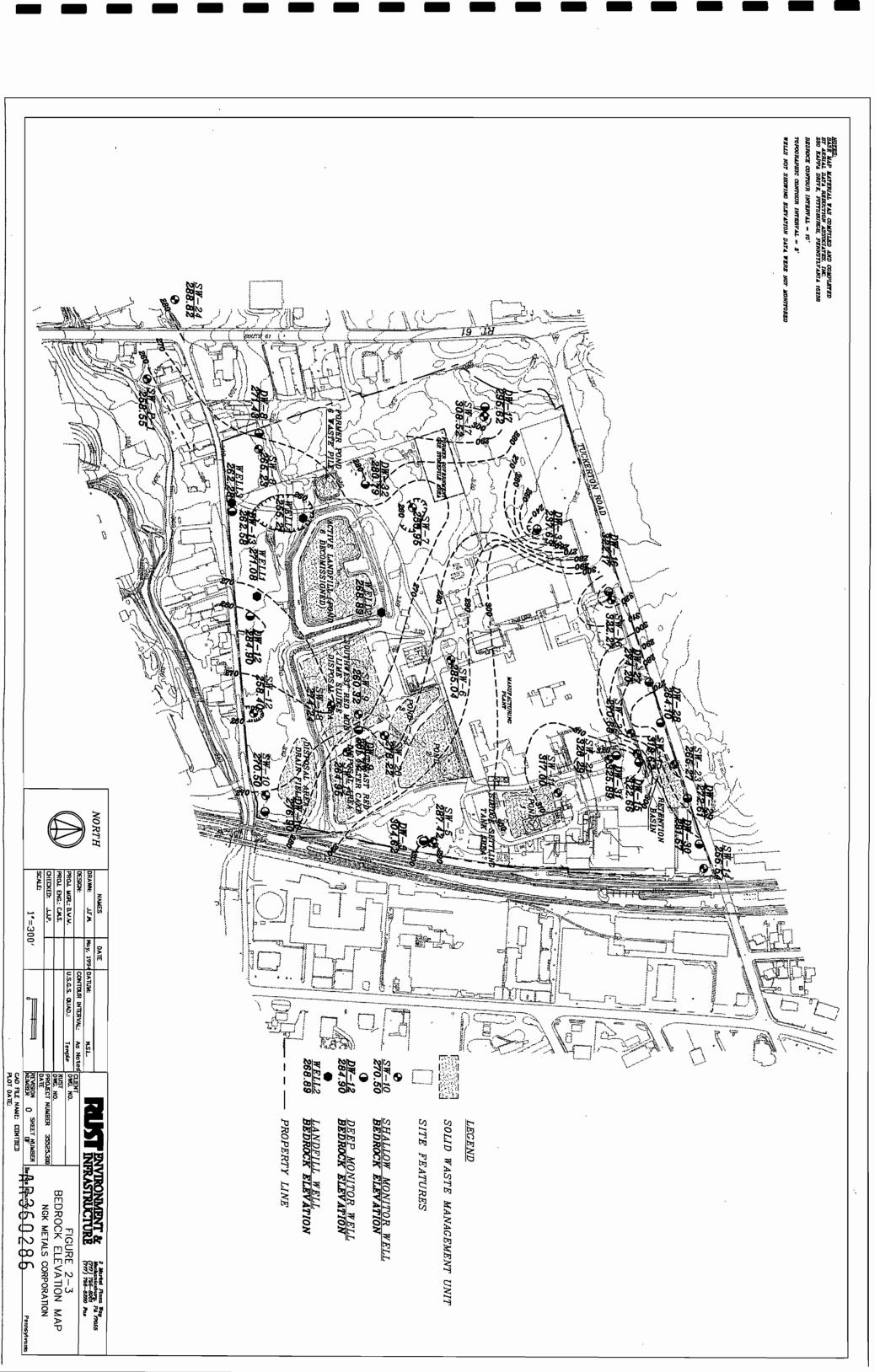
Typical bedrock is interbedded gray limestone and dolomite (occasionally referred to as dolostone) with occasional sandy and shaly zones, particularly near the northeastern portion of the site. The carbonate rock (i.e. limestone or dolomite) is almost always moderately to severely weathered and broken at the overburden/bedrock interface. Voids, and fractured or broken zones, are commonly encountered within the bedrock formation, and generally decrease in frequency with depth. Many of these voids and fractured zones are clay-filled and/or water-bearing zones. Top of bedrock information has been presented previously in other reports. The acquisition of additional top of bedrock data generated during the installation of the seven new monitor wells resulted in a revised bedrock elevation map, which is presented as Figure 2-3. These elevations are based on the first occurrence of weathered bedrock, generally limestone or dolomite, and were determined by field observations during well drilling and by interpretation of driller logs from pre-existing wells.

AR360283 May 1994











Lithologic data acquired from new wells in the northern section of the site are consistent with previous data, and this area of the site bedrock map remains relatively unchanged. Along the western property boundary, however, new data from wells DW-32 and DW-33 results in a significant modification to the bedrock map. The data indicate that while bedrock was encountered in new well DW-32 at 36 feet, competent bedrock in DW-33 was not achieved until 116 feet. Boulders and clay were encountered between 82 and 84 feet, and broken and severely weathered rock was encountered between 98 feet and 116 feet. These intermittent boulders and thick clay horizons are characteristic of sink hole zones.

The deep soil overburden horizon along with the severely weathered bedrock may be associated with the Tuckerton fault, which appears in previous site geologic maps. The approximate location of this fault traverses across Tuckerton Road in proximity (within approximately 400 feet) to the location of well DW-33. Published reports indicate that bedrock strikes approximately N65°E and dips roughly 42°S near the site. A measurement of N42°E/32°S was made in a bedrock pinnacle in the northwest corner of the site just east of well SW-17.

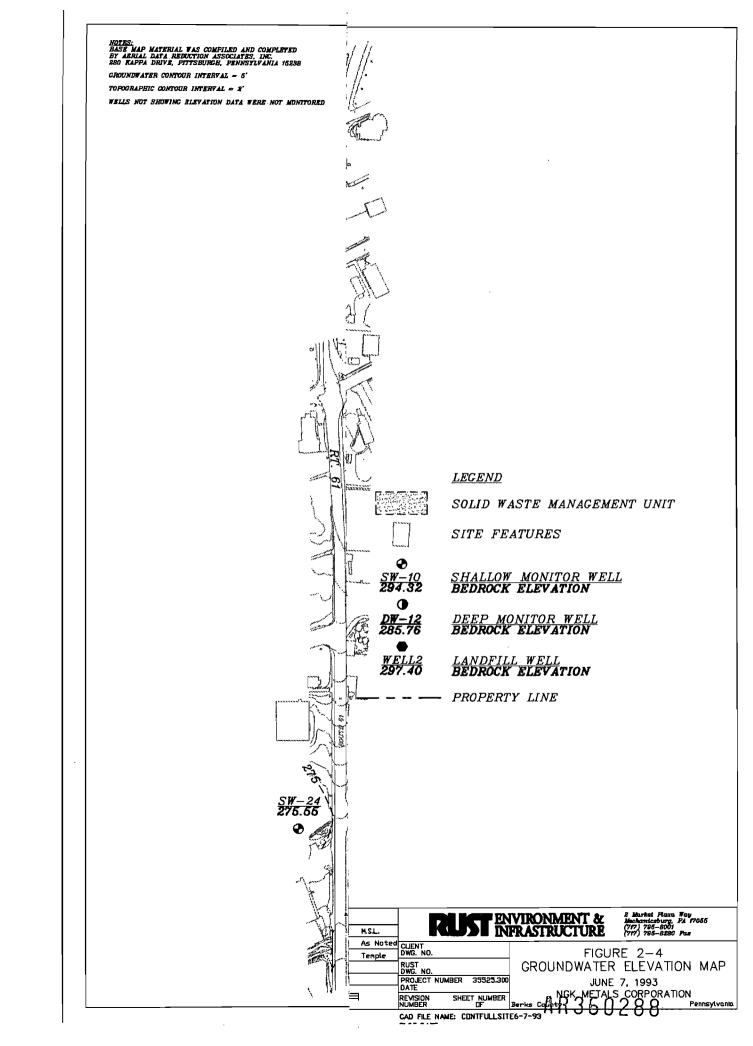
2.2 HYDROGEOLOGY/AOUIFER CHARACTERISTICS

Recent water level data (June 1993 and April 1994)) from existing on-site shallow and deep monitor wells are generally consistent with previous information, and continue to reflect slight differences in the shallow (i.e. <100 feet) and deep (i.e.>100 feet) aquifer zones. Groundwater elevations were calculated from these water levels and used to produce the contour maps presented as Figures 2-4 and 2-5, respectively. A slight elevation difference between the two zones is obvious, thus indicating an apparent (hydraulically) downward flow component from the upper aquifer zone towards the lower aquifer zone (recharge zone).

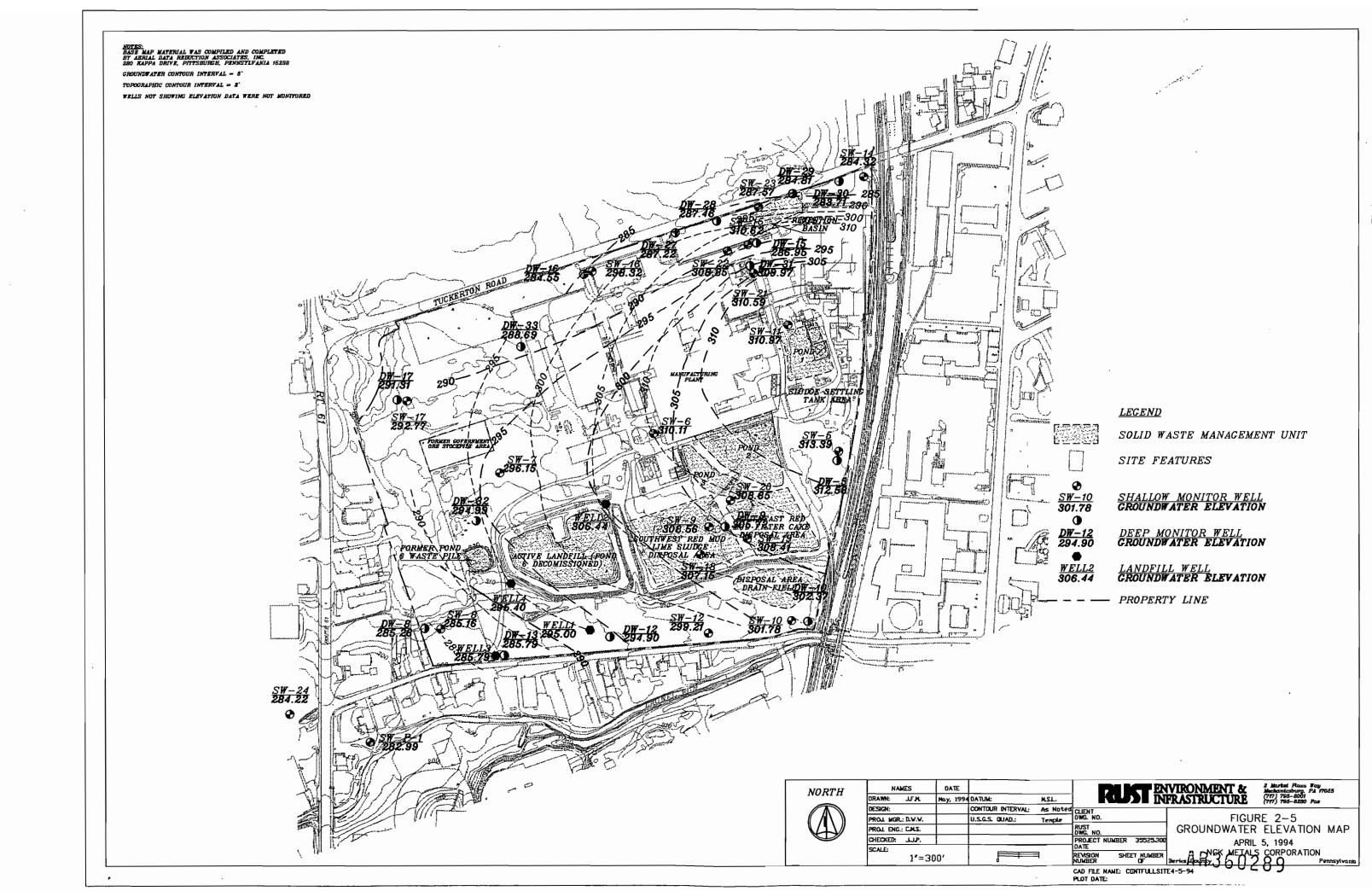
Newly acquired water level data confirm the groundwater flow patterns across the site that were established in earlier reports. Specifically, a groundwater divide essentially bisects the NGK site and trends roughly east to west. Groundwater flow within the shallow aquifer zone closely mimics the local topography. Generally, the groundwater elevation contours are more irregular (see Figures 2-4 and 2-5). The deeper aquifer zone typically reflects regional groundwater flow trends with the groundwater elevation contours generally more regular and consistent. Local flow in the southern portion of the site is generally towards Laurel Run. Regional groundwater flow is towards the Schuylkill River which, is generally to the west of the site. The Schuykill River is closest to the site approximately one-half mile to the northwest.

Previous reports have included discussions on three vertical zones within the water table aquifer proximal to and beneath the NGK site. These are the Unconsolidated Soil (soil) Zone, the Unconsolidated Soil/Bedrock Interface (interface and upper portion of broken weathered bedrock) Zone, and the Bedrock (deeper more competent bedrock) Zone. Prior aquifer test (i.e. slug tests) data indicate that the interface zone is generally the most hydraulically conductive of the three zones. Mean hydraulic conductivity estimates from available data are 8.0×10^{-1} ft/day, 3.3×10^{1} ft/day, and 4.9×10^{0} ft/day, respectively.

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Five of the seven new wells (DW-27 through DW-30 and DW-33) were constructed such that the screened interval spanned the overburden/bedrock interface zone. Shallow on-site wells are generally constructed across this interface. Despite this similarity, however, the water levels in the new wells are more consistent with those in the deep wells. This is likely due to the screened interval being within a larger portion of the bulk aquifer compared to any shallow well. New wells DW-31 DW-32 are constructed differently. Here, the screened intervals are totally within the bedrock zone.

2.3 GROUNDWATER WELL NETWORK

Initially, a total of thirty-one (31) monitor wells were installed as part of the NGK RFI study. Four (4) other monitor wells had existed prior to these wells as required by conditions established in the Industrial Landfill permit. Since the last report, the well labeling system has been revised. In previous reports shallow wells were labeled with an "A" (e.g. MW-5A) and deep wells carried a "B" label (e.g. MW-5B). This labeling system has been changed to eliminate any previous confusion as to which well is constructed within the shallow aquifer or deep aquifer. For this report and future reference, shallow wells are labeled "SW" and deep wells are "DW." A well correlation summary is presented in Table 2-1

TABLE 2-1
WELL CORRELATION SUMMARY

CTTA	TI	αm	XXZZZX	TC.
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DEEP WELLS:

Old Designation MW-5A MW-6A MW-7A MW-8A MW-9A MW-10A MW-11A MW-11A MW-12A MW-14A MW-15A MW-16A MW-17A	New Designation SW-5 SW-6 SW-7 SW-8 SW-9 SW-10 SW-11 SW-12 SW-14 SW-15 SW-16 SW-17	Old Designation MW-5B MW-8B MW-9B MW-10B MW-12B MW-13B MW-13B MW-15B MW-15B MW-16B MW-17B MW-25B MW-26B	New Designation DW-5 DW-8 DW-9 DW-10 DW-12 DW-13 DW-15 DW-15 DW-16 DW-17 DW-25 DW-26 DW-27
MW-18A MW-19A MW-20A MW-21A MW-23A MW-24A P-1 Well 1 Well 2 Well 3 Well 4	SW-18 SW-19 SW-20 SW-21 SW-23 SW-24 SW-P-1 unchanged unchanged unchanged unchanged	- - - - -	DW-28 DW-29 DW-30 DW-31 DW-32 DW-33

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Between June 1993 and March 1994, seven (7) new potential groundwater recovery wells, henceforth identified as DW-27, 28, 29, 30, 31, 32 and 33, were drilled and constructed primarily in two areas of the site based on the following information determined by previous site investigations:

- identified contaminant source areas;
- known groundwater flow direction(s);
- confirmed groundwater chemistry characteristics;
- aquifer characteristics determined by limited pump test results of existing wells SW-9, 19 and 15; and
- evaluation of the hydraulic behavior of aquifer materials proximal to and beneath the site through the use of a groundwater flow model.

Wells DW-27 through 30 span the northern property boundary along Tuckerton Road. Well DW-31 is located inside the plant area also in the northern portion of the site. Wells DW-32 and 33 are found along the west-central property boundary, which approaches PA Route 61 (Pottsville Pike). The rationale for the location of these new wells is generally associated with existing data gaps (e.g., aquifer characteristics, groundwater flow direction, groundwater chemistry) in specific areas of known contamination, and the lack of wells exhibiting sufficient yield in these same areas that could potentially be used for groundwater withdrawal. Previous investigations have determined that the pre-existing, as constructed wells located in the northern half of the site generally do not exhibit as high a yield as those wells constructed in the southern part of the site. Additionally, analytical data from the pre-existing monitor wells near the northern perimeter of the site indicate that groundwater has been adversely impacted by previous industrial activities.

Groundwater from wells located in the southern half of the site has also been impacted. However, a sufficient number of wells exist that produce adequate yields to be considered for use as effective groundwater withdrawal wells. Therefore, the principal area of new well installations was along the northern perimeter of the site. Additionally there appeared to be data gaps between monitor wells SW-7 and Well 4, and SW-7 and well set 16. Thus, new wells DW-32 and DW-33 were also established.

Five (5) of the new wells (DW-27 through DW-31) are located in proximity to an identified contaminant source, specifically, the former Retention Pond. A previously conducted seven (7) gallon per minute (gpm) pump test at monitor well SW-15 resulted in a maximum radius of influence of approximately 100 to 150 feet. Therefore, the anticipated area of influence created by pumping SW-15 alone was considered insufficient to effectively capture and contain contaminated groundwater in this area and to prevent off-site migration. The rationale for the

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additional new wells was based on the results of the SW-15 pump test and the need for potential groundwater recovery wells near a known source of groundwater contamination.

It was anticipated that the installation of the five new deeper wells would increase the likelihood of encountering higher yielding (i.e. >5 gpm) water bearing zones that exhibit hydraulic connection to the bulk aquifer system. In this way, effective hydraulic containment possibly could be achieved using fewer wells with larger effective areas of capture rather than more wells with smaller areas of capture.

New monitor wells DW-27 and 28 were installed between existing wells SW-16 and SW-23. The location of the new wells was also based on the pump test results on well SW-15, which, as stated above, indicated a radius of influence of approximately 100-150 feet. Therefore, it was essential that two additional wells be located in a manner that, if selected for use as recovery wells, would prevent migration of contamination from the Retention Pond area along the northern border of the site. The estimated yields of wells DW-27 and 28 are greater than 90 gpm and approximately 5 gpm, respectively.

New wells DW-29 and DW-30 were installed in the northeast corner of the site between existing wells SW-23 and SW-14. As mentioned above, pump testing of well SW-15 resulted in a radius of influence of approximately 100-150 feet. Therefore, wells DW-29 and DW-30 were spaced as close to this distance as practical. In this area of known groundwater contamination, neither of the two existing wells (SW-23 and SW-14) currently yield more than an estimated 5 gpm. According to published reports, the Leithsville Formation exists near the northwest corner of the site. Monitor well SW-14 is believed to be within this geologic formation, which is reportedly, conducive to high yielding wells. Although SW-14 is a moderate yielding well (approximately 3 gpm), DW-25, which is a deeper well (178 feet deep) and is located just north of the Blue Mountain Railroad Station, produces approximately 15 gpm. Based on this characteristic of the underlying bedrock, it was anticipated that the likelihood of one, if not both, of the new wells encountering sufficient (i.e. >5 gpm) yield was favorable. The objective of installing DW-29 and DW-30 was to install two new wells that would potentially yield more than any existing well in this area of the site. Estimated well yields of DW-29 and DW-30 are approximately 70 gpm and less than 2 gpm, respectively.

Deep well (i.e. greater than 100 feet) DW-31 was installed next to existing well SW-21. During the drilling and installation of monitor well SW-21, a void was encountered that caused a loss of drill hole materials (i.e. rock chips and water). The well was completed to 60 feet total depth. As a result of lost circulation, not much is known about the water yielding capabilities of this well. Well DW-31 was installed with the intent of encountering water-bearing zones with greater yield than any of the existing wells in this immediate area. The estimated yield of this well is less than 2 gpm.

Two deep wells, DW-32 and DW-33 were installed along the western property boundary in areas with insufficient data characterizing groundwater flow and quality. Well DW-32 was installed approximately mid-way between shallow wells SW-7 and (landfill) Well 4. The estimated well yield is 10 gpm. DW-33 was initially installed between well SW-7 and well set 16 within the

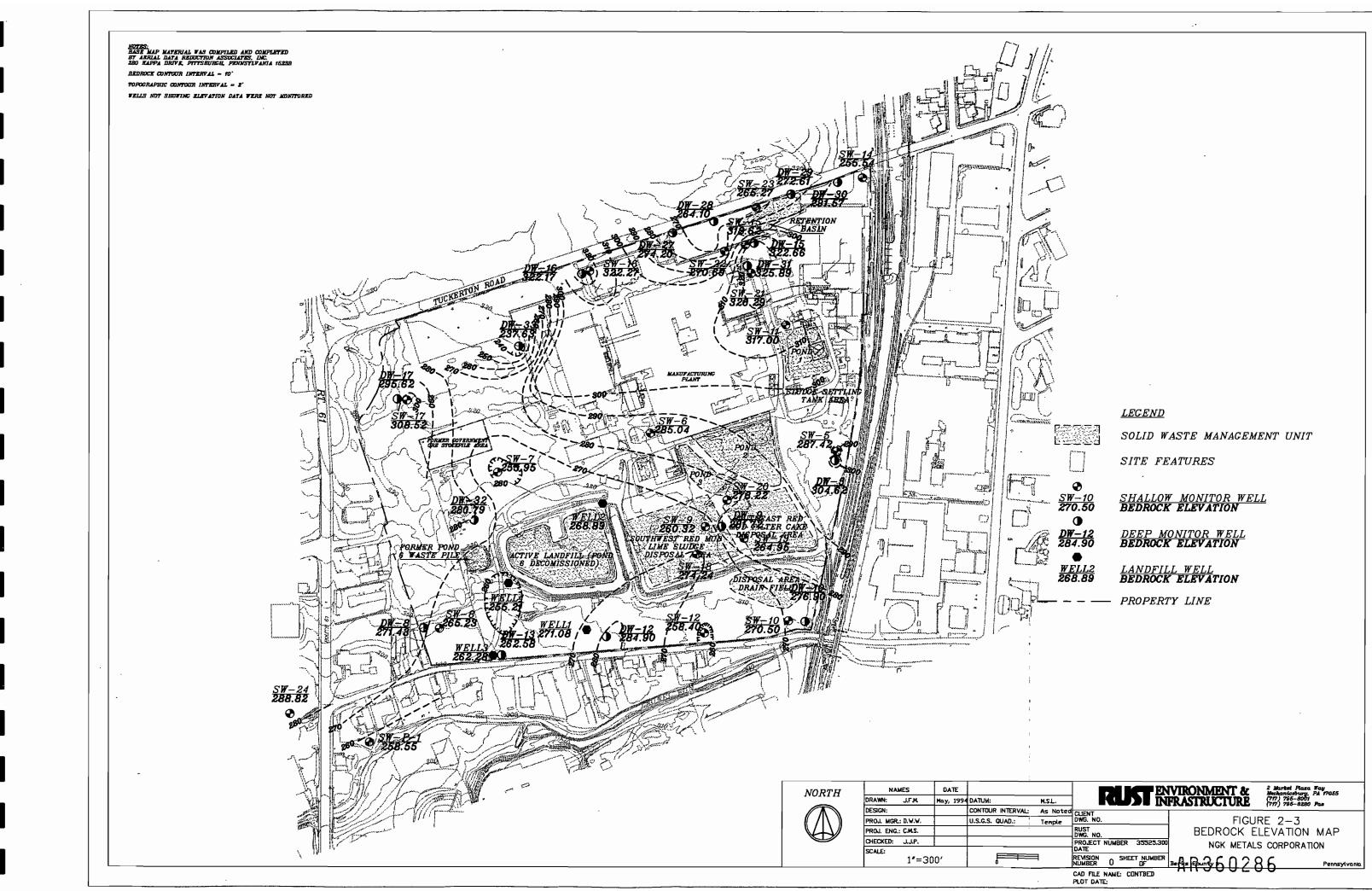
storage area along the fence near the northwestern corner of the site. This well was drilled to 150 feet and was essentially dry. The re-drilled well is located just outside the fence near the southeast corner of the employee parking lot. The well was developed and sampled at a 10 gpm rate during which the water level was only slightly effected. Well logs for the new and pre-existing wells are presented in Appendix A. Table 2-2 summarizes monitor well data including information from the new wells.

The installation, development and testing of new wells provides additional data collection points that supplement existing site characterization information. The seven (7) new wells are integrated into the existing well network, which is comprised of four (4) landfill (shallow) wells, twenty (20) shallow monitor wells (including off-site piezometer P-1) and seventeen (17) deep wells that are located on or adjacent to the site (shallow well SW-24, piezometer P-1 and deep well DW-25 are located within several hundred feet of the site). This network of wells was evaluated to select individual wells anticipated to be optimal for groundwater recovery in terms of sustainable pumping rates and the most effective capture of contaminated groundwater. Pump tests have been performed on select wells both in the northern and southern portions of the site. These data have been analyzed and are presented in the following section of this report.

TABLE 2-2
MONITOR WELL DATA SUMMARY

WELL	SURFACE ELEV.	TOC ELEV.	DEPTH TO BEDROCK	BEDROCK ELEV.	TOTAL DEPTH	SCREEN INTERVAL	WELL TYPE	ESTIMATED YIELD
	(ft. above MSL)	(ft. above MSL)	(feet)	(ft. above MSL)	(feet)	(feet)		(gpm)
Well I	306.08	308.08	35	271.08	50	24-50	8" slotted steel casing	30
Well 2	320.89	322.11	52	268.89	53	40-53	8" slotted steel casing	3
Well 3	302.28	304.24	40	262.28	55	30-55	8" slotted steel casing	15
Well 4	310.21	311.73	55	255.21	75	12-75	8" slotted steel casing	l
SW-5	327.42	329.56	40	287.42	48	28-48	4" PVC	>10
DW-5	327.62	329.62	23	304.62	175	100-175	6" open rock	2
SW-6	326.04	327.99	41	285.04	51	31-51	4" PVC	>5
SW-7	318.95	320.71	63	255.95	75	48-68	4" PVC	3
SW-8	303.23	304.71	38	265.23	61	37-57	4" PVC	25
DW-8	303.43	304.58	32	271.43	151	110-151	6" open rock	4
SW-9	Not measured	333.22	55	260.32	75	62-75	6" open rock	60
DW-9	Not measured	333.63	52	281.72	200	125-200	6" open rock	2
SW-10	311.5	312.8	41	270.50	41	21-41	4" PVC	3
DW-10	311.9	313.15	35	276.90	123	94-123	6" open rock	10
SW-11	328	330	11	317.00	73	20-73	6" open rock	3
SW-12	309.4	311.6	51	258.40	60	35-55	4" PVC	5
DW-12	305.9	307.83	21	284.90	160	100-160	6" open rock	150
DW-13	302.58	304.45	40	262.58	165	105-165	6" open rock	150
SW-14	326.54	327.97	71	255.54	76	48-68	4" PVC	3
SW-15	327.62	329.56	9	318.62	68	46.5-66.5	4" PVC	5
DW-15	327.66	329.63	5	322.66	175	118-175	6" open rock	<5
SW-16	327.27	328.74	5	322.27	75	12-75	6" open rock	2
DW-16	326.17	327.54	4	322.17	200	125-200	6" open rock	2
SW-17	319.52	321.16	11	308.52	75	20-75	6" open rock	2
DW-17	317.62	319.39	22	295.62	200	125-200	6" open rock	2
SW-18	Not measured	332.33	49	274.24	55.5	35.5-55.5	6" PVC	15-25
SW-19	Not measured	334.11	60	264.95	65	35-65	6" PVC	50
SW-20	Not measured	334.56	47	278.22	52	32-52	6" PVC	30
SW-21	329.79	331.99	3.5	326.29	60	25-60	2" PVC	NA
SW-22	328.19	330.39	57.5	270.69	72	32-72	4" PVC	4
SW-23	327.27	327.27	62	265.27	73	43-73	4" PVC	5
SW-24	298.82	298.82	10	288.82	63	33-63	4" PVC	5
DW-25	325.46	327.26	37	288.46	178	72-178	6" open rock	10
DW-26	283.28	284.48	39	244.28	202	42-202	6" open rock	3
DW-27	328.2	328.2	54	274.20	118	68-118	4" PVC	100
DW-28	327.1	327.1	63	264.10	120	70-120	4" PVC	4-5
DW-29	325.61	325.61	53	272.61	120	60-120	6" PVC	75
DW-30	325.57	326.51	34	291.57	121	60-120	4" PVC	2-4
DW-31	328.89	331.3	3	325.89	153	16-153	6" open rock	1
DW-32	316.79	319.49	36	280.79	157	59-150	6" open rock	10
DW-33	319.63	321.33	82	237.63	127	67-120	4" PVC	10
SW-P-1	300.55	302.35	>42	<258.55	45	35-40	2" PVC	15

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Between June 1993 and March 1994, seven (7) new potential groundwater recovery wells, henceforth identified as DW-27, 28, 29, 30, 31, 32 and 33, were drilled and constructed primarily in two areas of the site based on the following information determined by previous site investigations:

- identified contaminant source areas;
- known groundwater flow direction(s);
- confirmed groundwater chemistry characteristics;
- aquifer characteristics determined by limited pump test results of existing wells SW-9, 19
 and 15; and
- evaluation of the hydraulic behavior of aquifer materials proximal to and beneath the site through the use of a groundwater flow model.

Wells DW-27 through 30 span the northern property boundary along Tuckerton Road. Well DW-31 is located inside the plant area also in the northern portion of the site. Wells DW-32 and 33 are found along the west-central property boundary, which approaches PA Route 61 (Pottsville Pike). The rationale for the location of these new wells is generally associated with existing data gaps (e.g., aquifer characteristics, groundwater flow direction, groundwater chemistry) in specific areas of known contamination, and the lack of wells exhibiting sufficient yield in these same areas that could potentially be used for groundwater withdrawal. Previous investigations have determined that the pre-existing, as constructed wells located in the northern half of the site generally do not exhibit as high a yield as those wells constructed in the southern part of the site. Additionally, analytical data from the pre-existing monitor wells near the northern perimeter of the site indicate that groundwater has been adversely impacted by previous industrial activities.

Groundwater from wells located in the southern half of the site has also been impacted. However, a sufficient number of wells exist that produce adequate yields to be considered for use as effective groundwater withdrawal wells. Therefore, the principal area of new well installations was along the northern perimeter of the site. Additionally there appeared to be data gaps between monitor wells SW-7 and Well 4, and SW-7 and well set 16. Thus, new wells DW-32 and DW-33 were also established.

Five (5) of the new wells (DW-27 through DW-31) are located in proximity to an identified contaminant source, specifically, the former Retention Pond. A previously conducted seven (7) gallon per minute (gpm) pump test at monitor well SW-15 resulted in a maximum radius of influence of approximately 100 to 150 feet. Therefore, the anticipated area of influence created by pumping SW-15 alone was considered insufficient to effectively capture and contain contaminated groundwater in this area and to prevent off-site migration. The rationale for the

Lithologic data acquired from new wells in the northern section of the site are consistent with previous data, and this area of the site bedrock map remains relatively unchanged. Along the western property boundary, however, new data from wells DW-32 and DW-33 results in a significant modification to the bedrock map. The data indicate that while bedrock was encountered in new well DW-32 at 36 feet, competent bedrock in DW-33 was not achieved until 116 feet. Boulders and clay were encountered between 82 and 84 feet, and broken and severely weathered rock was encountered between 98 feet and 116 feet. These intermittent boulders and thick clay horizons are characteristic of sink hole zones.

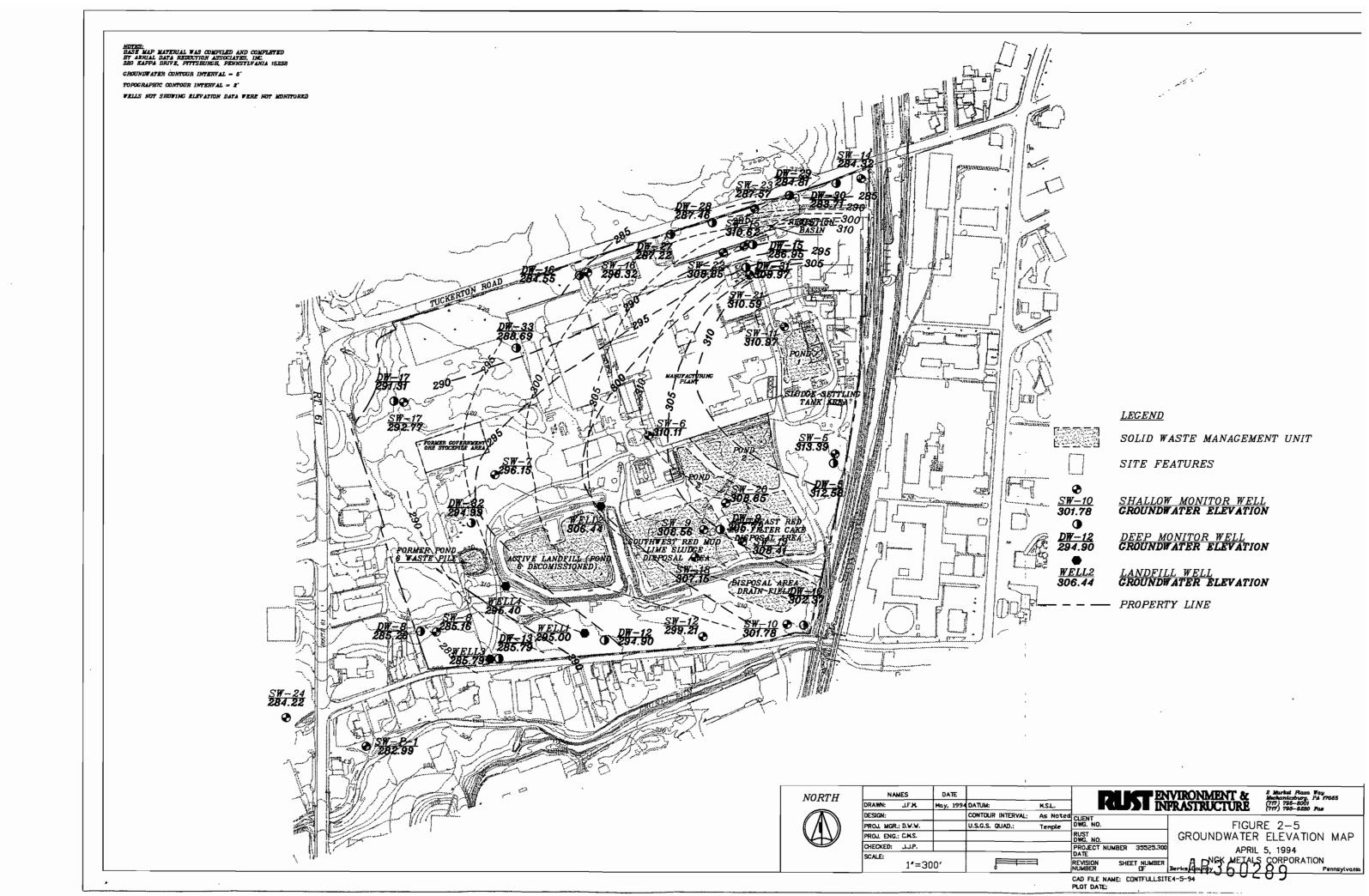
The deep soil overburden horizon along with the severely weathered bedrock may be associated with the Tuckerton fault, which appears in previous site geologic maps. The approximate location of this fault traverses across Tuckerton Road in proximity (within approximately 400 feet) to the location of well DW-33. Published reports indicate that bedrock strikes approximately N65°E and dips roughly 42°S near the site. A measurement of N42°E/32°S was made in a bedrock pinnacle in the northwest corner of the site just east of well SW-17.

2.2 HYDROGEOLOGY/AQUIFER CHARACTERISTICS

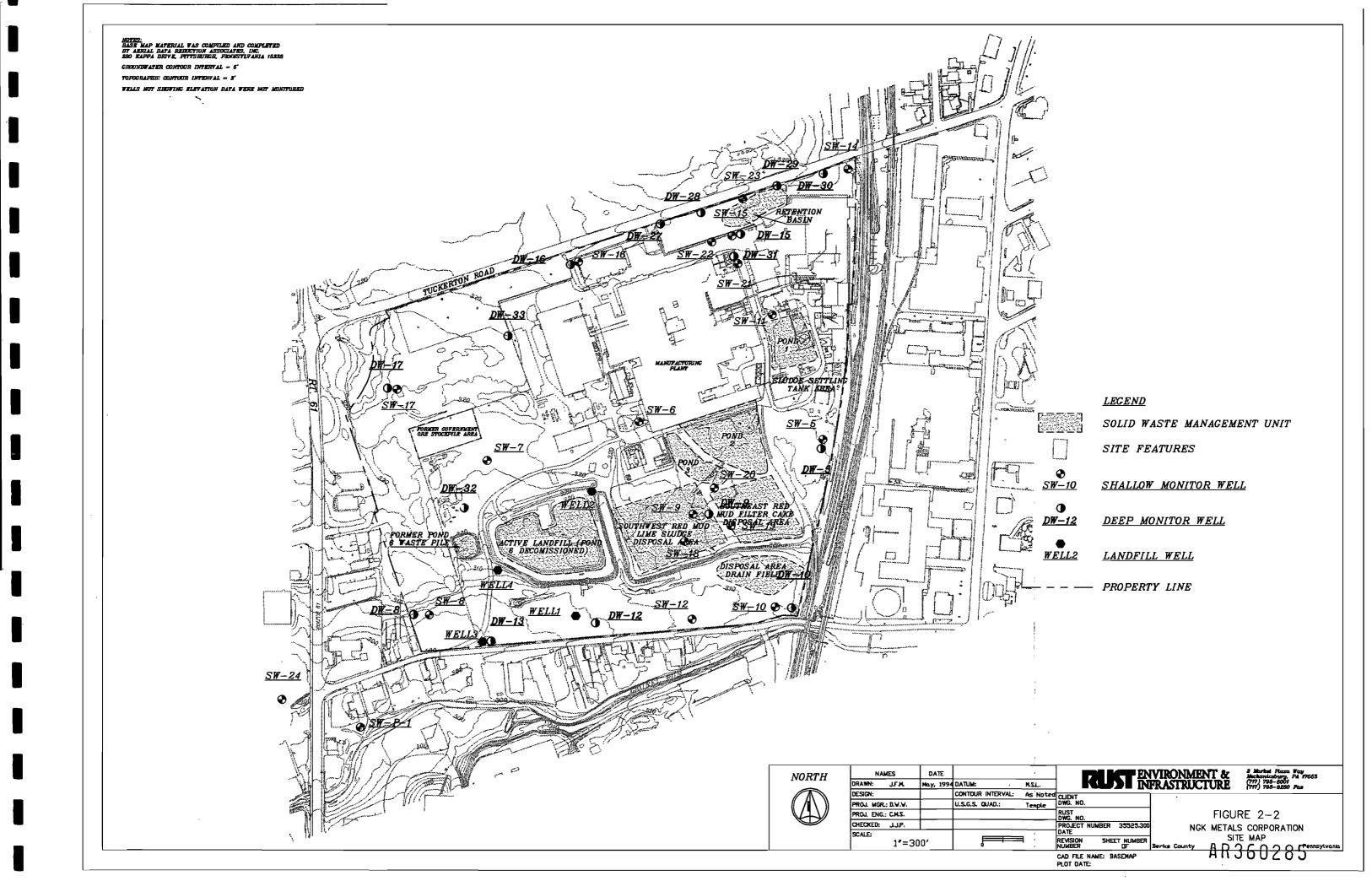
Recent water level data (June 1993 and April 1994)) from existing on-site shallow and deep monitor wells are generally consistent with previous information, and continue to reflect slight differences in the shallow (i.e. <100 feet) and deep (i.e.>100 feet) aquifer zones. Groundwater elevations were calculated from these water levels and used to produce the contour maps presented as Figures 2-4 and 2-5, respectively. A slight elevation difference between the two zones is obvious, thus indicating an apparent (hydraulically) downward flow component from the upper aquifer zone towards the lower aquifer zone (recharge zone).

Newly acquired water level data confirm the groundwater flow patterns across the site that were established in earlier reports. Specifically, a groundwater divide essentially bisects the NGK site and trends roughly east to west. Groundwater flow within the shallow aquifer zone closely mimics the local topography. Generally, the groundwater elevation contours are more irregular (see Figures 2-4 and 2-5). The deeper aquifer zone typically reflects regional groundwater flow trends with the groundwater elevation contours generally more regular and consistent. Local flow in the southern portion of the site is generally towards Laurel Run. Regional groundwater flow is towards the Schuylkill River which, is generally to the west of the site. The Schuykill River is closest to the site approximately one-half mile to the northwest.

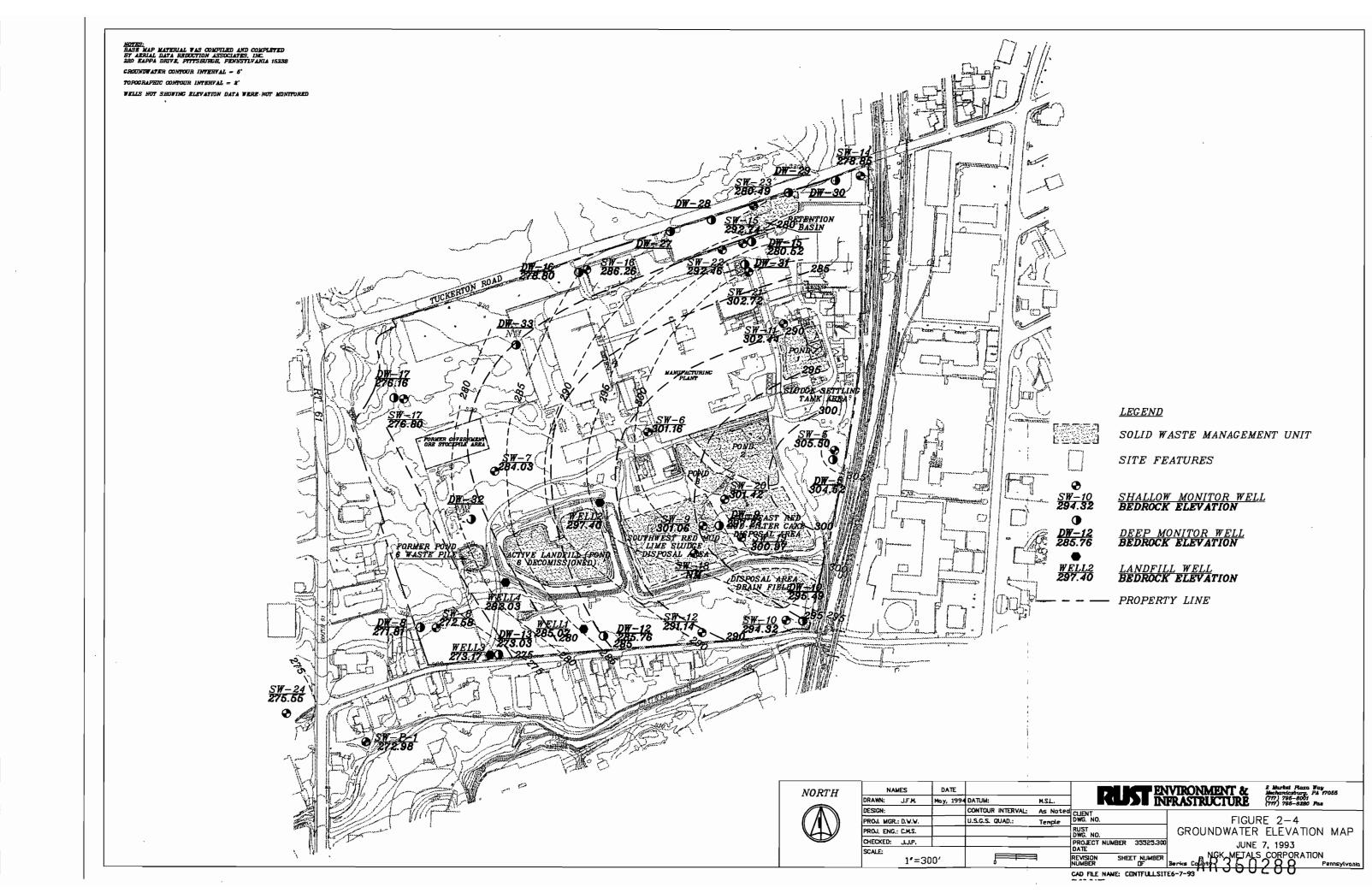
Previous reports have included discussions on three vertical zones within the water table aquifer proximal to and beneath the NGK site. These are the Unconsolidated Soil (soil) Zone, the Unconsolidated Soil/Bedrock Interface (interface and upper portion of broken weathered bedrock) Zone, and the Bedrock (deeper more competent bedrock) Zone. Prior aquifer test (i.e. slug tests) data indicate that the interface zone is generally the most hydraulically conductive of the three zones. Mean hydraulic conductivity estimates from available data are 8.0×10^{-1} ft/day, 3.3×10^{1} ft/day, and 4.9×10^{0} ft/day, respectively.













3.0 AQUIFER TEST ANALYSIS

3.1 INTRODUCTION

Based on previous investigations, seven additional on-site wells were installed to provide appropriate data used to establish flow characteristics for the pumping and containment of contaminated groundwater, should they be included in the overall site well network of groundwater extraction wells. Specifically, these wells were installed to measure drawdown effects caused by pumping of select wells. The monitor wells were spaced with the intent that areas of influence could be sufficiently delineated.

After the new wells were installed and developed, informal step-drawdown tests were conducted on wells considered appropriate for use as potential groundwater recovery wells. New wells DW-27, DW-28, DW-29 and DW-32 were step-tested to evaluate well performance and to select an appropriate pumping rate for drawdown tests. These wells were selected based on the approximate well yields, which were estimated at the time of drilling and proximity to known source areas. In addition, step-drawdown tests were also completed on previously existing wells SW-8, DW-12 and DW-13, located on the southern portion of the site. These wells had not been previously tested and, because of their location and estimated yield, were anticipated to be included in the network of groundwater recovery wells based on pump test performance and results. Finally, after each well was step tested a drawdown/recovery test was performed and analyzed to evaluate the respective areas of influence. These areas of influence are key elements in the design of an appropriate and effective network of groundwater recovery wells that results in the prevention of off-site migration of contaminated groundwater.

3.2 STEP-DRAWDOWN TESTING

Prior to each of the respective drawdown tests, each well was step-drawdown tested at variable pumping rates. The data generated provided for an initial evaluation of the performance of each respective pumping well. A cursory review of each test is discussed below, and focuses on the actual performance of the respective pumping well rather than presenting a comprehensive quantitative analysis of each of the individual step-drawdown tests. The ultimate goal of each step-drawdown test was to establish optimal pumping rates that could be sustained for the respective minimum 3-day drawdown test planned, and result in maximum amount of drawdown in monitored observation wells.

3.2.1 SW-8

During the step-drawdown test, pumping rates of 10, 20, 30 and 40 gpm were selected to evaluate well performance. Each step was run for 30 minutes except for the 40 gpm test, which lasted for 10 minutes. The water level dropped to the pump intake during the 40 gpm test and

the pumping rate dropped to approximately 30 gpm. The test was terminated at this point. The test data indicated that the well was capable of sustaining a flow rate of approximately 30 gpm, which would result in maximum drawdown within the well. It was determined that the well could be stressed at this rate for the desired minimum 3-day period. A pumping rate of 30 gpm for the drawdown test was chosen.

3.2.2 DW-12

Pumping rates of 30, 60 and 96 gpm were chosen to evaluate well performance for well DW-12. The first step lasted nearly 60 minutes while the last two steps ran for roughly 30 minutes. The 96 gpm rate was the highest achievable with the available pump. The increased pumping rate resulted in no additional drawdown. Therefore, based on these results and the well yield estimated during the time of installation, a pumping rate of 120 gpm was selected for the drawdown test.

3.2.3 DW-13

Based on the estimated well yield determined during well installation, step-drawdown pumping rates of 60 and 96 gpm were chosen to evaluate well performance. The 96 gpm rate was the highest achievable with the available pump. The well was expected to sustain this pumping rate throughout the desired minimum three-day drawdown test period.

3.2.4 DW-27

The performance of well DW-27 was evaluated for variable pumping rates of 15, 30, 45, 60, 75 and 92 gpm. The response of the well to these rates over 60 minute intervals indicated that the well was capable of sustaining a flow rate of at least 90 gpm for the drawdown test.

3.2.5 DW-28

Well DW-28 was step-drawdown tested at pumping rates of 9, 18 and 27 gpm. The pumping rates chosen were based on an initial estimated well yield of approximately 10 gpm. Test results indicated that the well could sustain a flow rate less than 9 gpm for the desired three-day drawdown test. A flow rate of 8 gpm was chosen.

3.2.6 DW-29

A step-drawdown test of varying rates was completed to evaluate well performance. Based on well yield estimates, DW-29 was tested at 60 and 98 gpm for approximately 30 minutes each step. Based on the water level response to each pumping rate, a pump capable of greater pumping rates was deemed necessary. The step-drawdown test results indicated that the well was capable of sustaining a pumping rate of greater than 98 gpm. A pump capable of up to 150 gpm was used during the drawdown test.

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Page 3-2

3.2.7 DW-32

Well yield estimated during the time of well drilling and installation was approximately 10-20 gpm. The step-drawdown test was performed at 5 and 7 gpm. The desired 10 gpm flow rate for the second step was not achieved due to pump limitations. Significant drawdown occurred even at 7 gpm. Therefore, initial well yield estimates were higher that actual well yield. A pumping rate of 9 gpm was selected for the drawdown test after a larger pump was installed.

3.3 DRAWDOWN/RECOVERY TESTING

After the respective step-drawdown tests were completed to evaluate the performance of each individual well, a drawdown test was conducted and immediately followed by a recovery test. The primary purpose of drawdown/recovery testing the potential groundwater recovery wells was to collect water level response data, which were used to select wells appropriate for use in a groundwater hydraulic containment system. Each drawdown test was performed over a minimum of approximately 72 hours. Drawdown tests of a duration of over a three-day period were expected to provide sufficient data to delineate areas of influence, degree of influence, and evaluate aquifer behavior characteristics. These data are essential for the development of an effective and efficient groundwater recovery well network. Pump test data are included in Appendix B.

Well DW-13 was tested for nearly seven days and the drawdown test on DW-12 lasted for approximately five days. Drawdown tests for wells DW-27 and DW-32 lasted four days while SW-8, DW-28 and DW-29 were tested for three days.

Graphical displays of pump drawdown test results are presented with each individual well test discussion that follows. Where appropriate, the respective measured drawdowns have been corrected and are plotted to account for natural area-wide groundwater level trends. The graphs typically reflect natural draining of the aquifer during periods of little precipitation or periods of infiltration due to seasonal precipitation events. A decline in water levels is denoted graphically by a negative-sloped line and a rise in water levels by a positive-sloped line (water levels versus time). Figures 1 through 7 in Appendix C show the pre-test water levels for pump tests on wells SW-8, DW-12, DW-13, DW-27, DW-28, DW-29, and DW-32.

Groundwater level data collected during drawdown/recovery testing of wells SW-8, DW-12, DW-13, DW-28, and DW-29 were primarily affected by naturally declining water levels. As a result, the corrected drawdowns are generally less than the measured drawdowns. Conversely, while drawdown/recovery testing wells DW-27 and DW-32, the water level trend was variable and drawdown adjustments were not appropriate. Corrections were only made when the water level trends continue throughout the entire duration of the pump test without significant variability. Therefore, drawdowns were not corrected for wells DW-27 and 32. The variable water level data were coincident with precipitation events coupled with a significant snow pack melt. The changes in slope on Figures 6 and 7 correspond to the variable groundwater recharge

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and discharge episodes. Corrected and uncorrected drawdowns for the respective pump tests are summarized on Table 3-1.

The effects of conducting step-drawdown tests prior to the startup of respective drawdown (pump) tests is seen on some of the graphs in Appendix B. In these instances, water level correction factors, when applied, were determined by pre-step drawdown test trends.

3.3.1 SW-8

Drawdown/recovery testing was performed by withdrawing groundwater from well SW-8 at an average rate of approximately 28 gpm. The pump test was conducted from August 16 to August 19, 1993. The initial pumping rate was set at 30 gpm, and after approximately 1210 minutes of pumping the rate fell to roughly 25 gpm. At this point the water level had dropped within the well to the pump intake, but the 25 gpm yield was sustained. Drawdown testing lasted for a total of 4356 minutes. Drawdown in well SW-8 reached a maximum of nearly 14 feet. This drawdown was generally maintained until the termination of the test. Wells DW-8, DW-12, DW-13, SW-7, SW-24, SW-P-1, Well 1, Well 3, and Well 4 were also monitored. Figures 3-1 and 3-2 illustrate the water level responses for each of the observed wells.

Water levels in monitor wells Well 3, DW-13 and DW-8 showed the most decline due to pumping. Corrected drawdowns in these wells were 1.30, 1.25, and 1.15 feet, respectively. Well 4 showed a decline of 0.25 feet, which is possibly due to pumping. Water levels in monitor wells SW-24 and SW-P-1, that are located just off-site towards the southwest, were rising. Rising water levels are contrary to the expected response due to pumping. Therefore, these two shallow wells were unaffected by pumping of well SW-8. Although, the cyclic pattern for SW-24 plot suggests that this well may be impacted by a nearby pumping well. Reportedly, there are groundwater production wells located within the tank farm located less than 2000 feet south of well SW-24. Pre-test groundwater elevation data are shown on Figure 3-3. In comparison, the maximum drawdown groundwater elevations that resulted from the pumping of SW-8 are shown on Figure 3-4.

The water level drop in Well 3 was slightly more than in observation wells DW-8 and DW-13. Well 3, like pumping well SW-8, is set within the shallow aquifer system (i.e. less than 100 feet deep). During the early portion of the drawdown test, at about 900 minutes, the water level in Well 3 rose nearly 0.5 feet, peaked at approximately 1200 minutes then continued to decline until the recovery portion of the test. This pattern may be indicative of period of infiltration caused by a precipitation event that occurred approximately two days earlier.

The remaining wells, DW-8 and DW-13 are constructed within the deep aquifer system, which is considered more than 100 feet below the ground surface. The corrected drawdown data from pumping SW-8 are summarized below in Table 3-2.

TABLE 3-1 DRAWDOWN DATA SUMMARY

PI	UMPING WELL SW-	8	PU	MPING WELL DW-1	2	Pl	JMPING WELL DW-	13
Well	Drawdown	Corrected DD	Well	Drawdown	Corrected DD	Well	Drawdown	Corrected DD
SW-8	14.04	13.69	DW-12	42.86	42.11	DW-13	38.29	38.29
Well 4	0.62	0.25	SW-12	3.96	3.36	Well 3	19.01	19.01
DW-13	1.67	1.25	Well 4	6.49	6.16	DW-12	2.65	1.24
Well 1	0.26	-0.13	Well 1	12.04	11.73	Well 1	2.38	1.01
DW-8	1.57	1.15	DW-13	2.74	2.33	Well 4	3.94	2.39
Well 3	1.70	1.30	SW-5	-0.25	-0.97	SW-8	7.10	7.10
SW-7	0.42	-0.04	DW-5	0.17	-0.60	DW-8	9.07	9.07
DW-12	0.16	-0.26	SW-6	0.35	-0.03	SW-5	0.22	-1.08
SW-P-1	-0.11	-0.11	SW-7	1.17	0.72	DW-5	0.24	-1.02
SW-24	-3.28	-3.28	SW-8	2.12	1.81	SW-6	1.89	1.89
			DW-8	1.20	0.81	SW-7	2.30	0.85
			SW-9	0.66	-0.03	SW-9	1.64	0.23
			DW-9	1.08	0.62	DW-9	1.30	0.07
			SW-10	-0.08	-1.03	SW-10	0.72	-0.59
PU	MPING WELL DW-2	27	DW-10	1.06	-0.11	DW-10	-0.19	-1.50
			SW-19	0.63	-0.01	SW-12	1.58	0.48
Weil	Drawdown	Corrected DD	SW-20	0.60	-0.04	SW-18	1.63	0.06
DW-27	32.84	32.84	SW-24	-2.93	-2.93	SW-19	1.62	0.21
SW-16	-2.71	-2.71	SW-P-1	2.48	2.48	SW-20	1.57	-0.07
DW-28	7.36	7.36	Well 2	0.86	-0.01	SW-24	-4.57	-4.57
SW-22	0.28	0.28	Well 3	2.68	2.24	Well 2	2.06	0.32
SW-15	-0.70	-0.70				SW-P-1	-0.69	-0.69
DW-15	2.03	2.03						
SW-23	3.06	3.06	PU	APING WELL DW-2	8			
DW-16	-0.55	-0.55		_			PUMPING WELL	DW-29
			Well DW-28	Drawdown 40.40	Corrected DD 40.40	Well	Drawdown	Corrected DD
			SW-15	0.56	0.24	DW-29	41.39	41.28
			SW-23	0.91	0.91	SW-15	0.45	0.21
DIII	MPING WELL DW-3	2	DW-15	0.51	0.51	SW-23	3.66	2.95
7 01	WIT HING WELL DW-5	٤	DW-13	0.72	0.52	DW-15	6.17	6.06
Well	Drawdown	Corrected DD	SW-22	0.82	0.41	DW-28	2.21	1.57
DW-32	63.19	63.19	SW-29	-0.13	-0.13	DW-30	3.90	3.66
DW-32 DW-13	0.71	0.71	SW-29	0.89	0.02	SW-14	2.78	2.58
Well 3	0.70	0.70	DW-5	0.88	0.05	SW-5	1.45	-0.15
SW-8	0.62	0.62	SW-6	0.74	-0.01	DW-5	1.21	-0.25
DW-8	0.05	0.05	SW-7	0.35	-0.08	SW-11	1.10	-0.03
SW-7	2.28	2.28	SW-11	0.83	-0.05	SW-16	0.36	-0.02
	0.76	0.76	SW-14	0.03	0.03	DW-16	0.57	0.30
Well 2 Well 4	0.76 0.77	0.76	SW-14 SW-16	0.03	0.05	SW-17	0.27	-0.02
Well 4	0.77	0.77	5W-16 DW-16	0.35	0.05	DW-17	0.27	0.18
						SW-21		
National National		. Lavrada . a a	SW-17	0.34	0.07		0.37	0.02
•	values indicate water	levels are	DW-17	0.42	-0.02	SW-22	0.64	0.34
higher tha	an at pump startup		SW-21	7.79	7.06	DW-25	0.02	-0.18
			DW-25	-0.16	-0.16	DW-27	1.07	0.31
			DW-30	-0.07	-0.07	DW-31	0.37	0.13
			DW-31	1.29	0.80			

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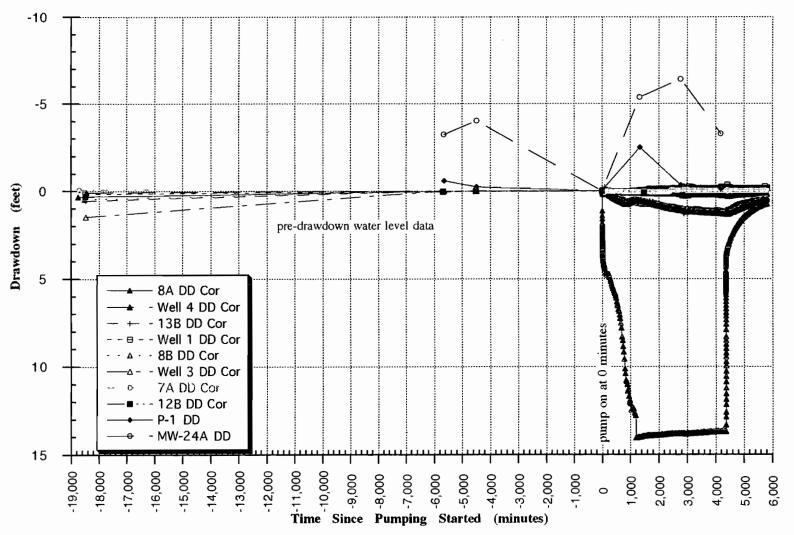


Figure 3-1
Pre-Test/Drawdown/Recovery Test Graph
for Pumping Well MW-8A

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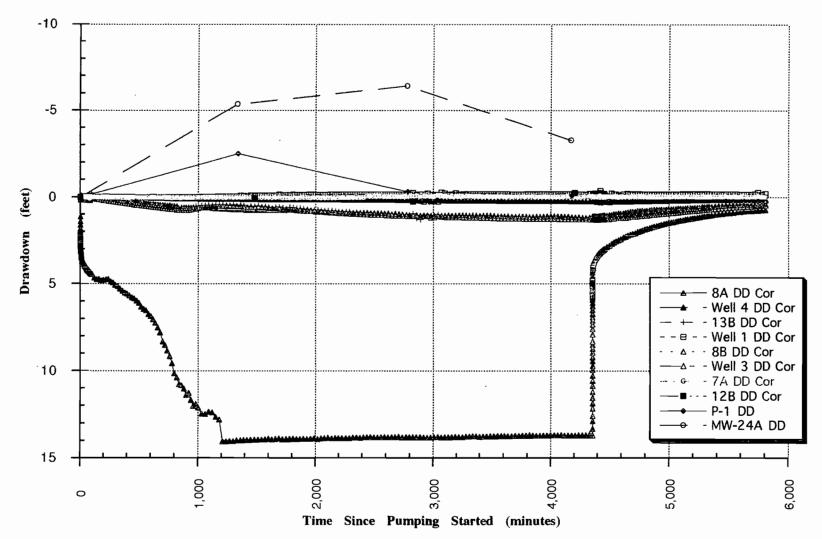
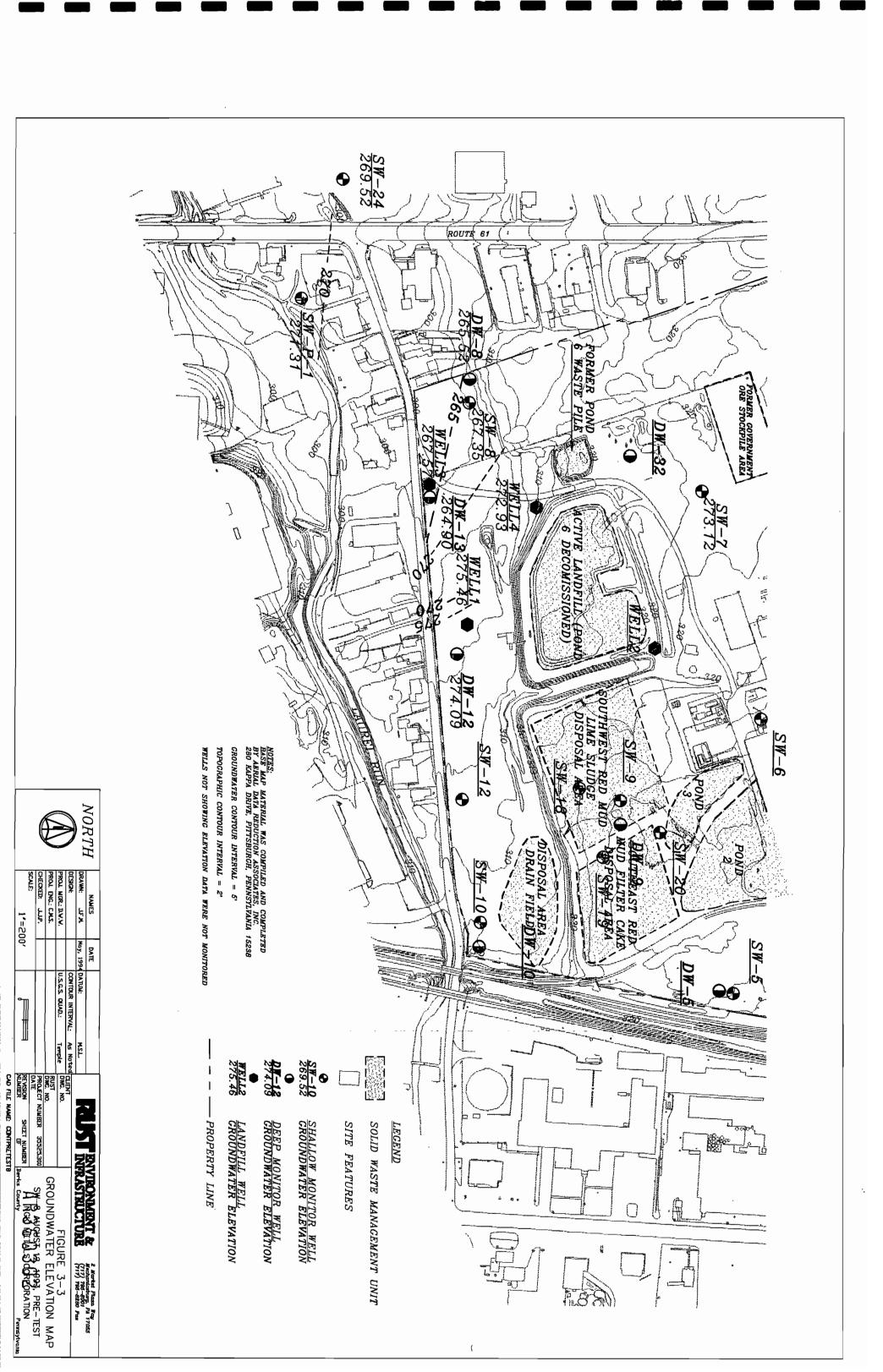


Figure 3-2 Drawdown/Recovery Test Graph for Pumping Well MW-8A

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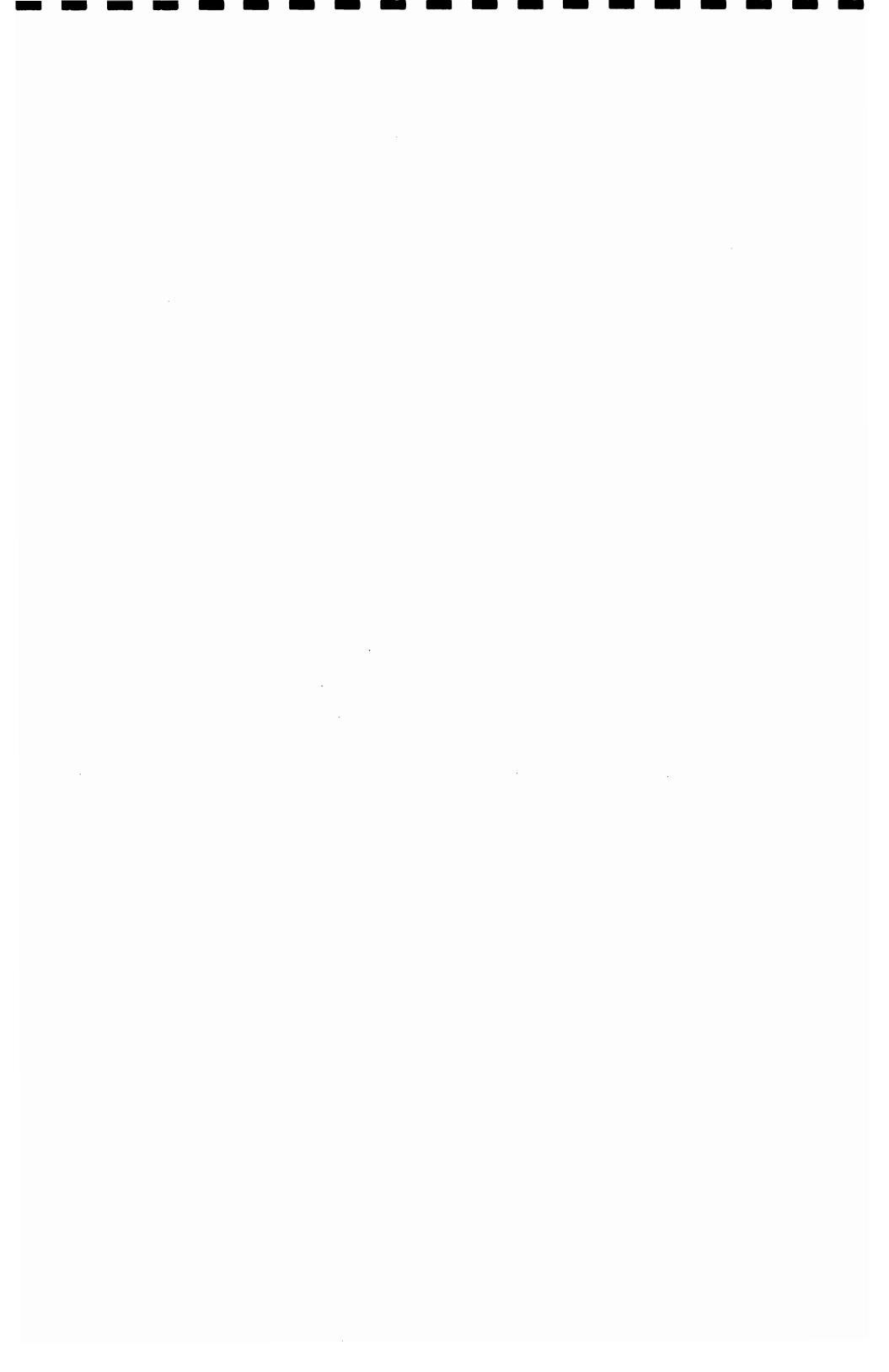


TABLE 3-2

DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL SW-8

<u>WELL</u>	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM SW-8 (ft.)
SW-8	13.69	0.33
DW-8	1.15	15
Well 3	1.30	223
DW-13	1.25	250
Well 4	0.25	305

Upon completion of the drawdown test, water level recovery data were collected. The recovery test terminated after the water level reached approximately 92% of total recovery. One small rain event of 0.17 inches occurred on the day after pumping began. No other precipitation fell during the remaining drawdown test or subsequent recovery test. Available precipitation data from the nearest reporting weather station, which is located at the Allentown-Bethlehem-Easton airport approximately 25 miles to the northeast, along with a plot of these data are found in Appendix D.

3.3.2 DW-12

Drawdown/recovery testing was performed by withdrawing groundwater from well DW-12 at an average rate of 105 gpm. The drawdown test ran from July 15 to July 19, 1993. The initial pumping rate was set at 120 gpm, and gradually the rate fell to roughly 110 gpm at the end of the test with periodic lows of 95 gpm. Well DW-12 is a 6-inch open rock well with open interval (uncased) from 100 feet to 160 feet. Groundwater extracted from the well during prior sampling and well development events has historically been turbid. Available information indicates that the turbid conditions may likely continue as a result of extended pumping of this well because the open rock section intersects a muddy, clay-filled void from 155 to 160 feet. Therefore, as a precautionary measure, 4-inch diameter slotted PVC screen was lowered into the borehole prior to the drawdown tests on the well to reduce the risk of borehole collapse. In addition, the screen prevented any loose fragments of the surrounding formation from potentially passing through the pump, which would affect pump performance. A 4-inch diameter screen was the largest commonly available type that would accommodate the nominal borehole diameter. A centrifugal submersible pump capable of pumping up to 150 gpm was used to conduct the tests. This pump was selected because it would fit into the 4-inch diameter PVC, and provide an adequate flow rate for the drawdown test.

Because of limited space between the pump intake and the inner PVC screen surface, it is believed that groundwater flow was restricted during the drawdown test. As a result, recorded

drawdown within the screen was enhanced due to well inefficiency. The maximum recorded and corrected (for natural water level trend) drawdown was just slightly more than 42 feet. The actual drawdown, which was spot checked within the space between the screen and the borehole with and electric drop line monitoring device, showed a discrepancy from the recorded drawdown of approximately 20 feet. Several other water level checks were unreliable water levels due either to the probe hanging up or cascading water along the borehole, which produced false water level readings. The relationship between measured and recorded drawdowns was not linear, and therefore, not correctable. Irrespective of the actual drawdown, the sustained pumping of well DW-12 over a period of approximately 5650 minutes produced favorable results in terms of measurable drawdown in distant observation wells.

Water levels in a total of six monitor wells dropped more than one foot, and was due to pumping of well DW-12. Although the (corrected) drawdown in well DW-8 was less than one foot (0.81 feet), this drop is likely due to pumping DW-12. Piezometer P-1 dropped 2.24 feet, however, it is undetermined whether this is attributable to pumping DW-12. Drawdown results are shown on Figures 3-5 and 3-6. Recorded (corrected) drawdowns in shallow wells and deep wells are as follows:

TABLE 3-3

DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-12

<u>WELL</u>	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM DW-12 (ft.)
DW-12	42.11	0.25
Well 1	11.73	76
SW-12	3.36	359
DW-13	2.33	391
Well 3	2.24	423
Well 4	6.16	409
DW-9	0.62	583
SW-8	1.81	617
DW-8	0.81	632
SW-7	0.72	723

The relationship of distance and groundwater elevations before the pump was turned on and near maximum drawdown in the pumping well are shown on Figures 3-7 and 3-8. The impact of pumping well DW-12 on the shallow and deep water level systems is shown by the inflection of the shallow water level contours and by the concentric closed deep water level contours.

A recovery test was conducted immediately after the completion of the drawdown test of well DW-12. The water level in DW-12 reached approximately 87% recovery before data logging

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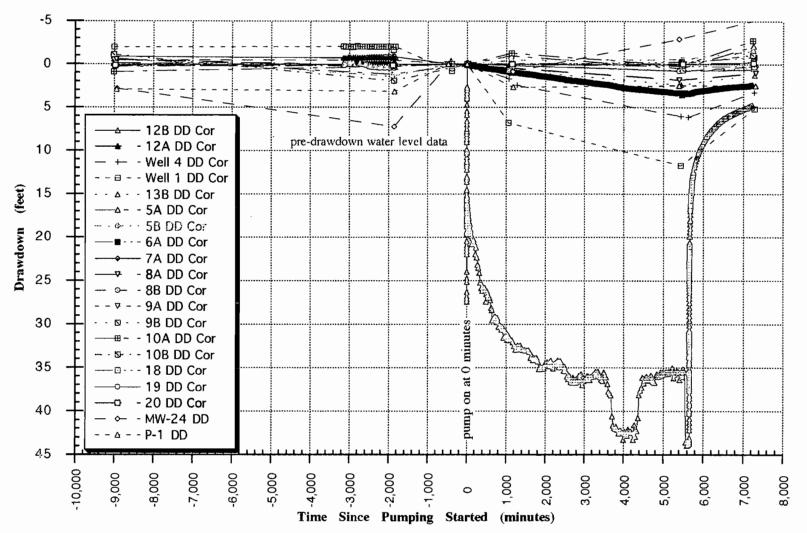


Figure 3-5
Pre-Test/Drawdown/Recovery Test Graph for Pumping Well MW-12B

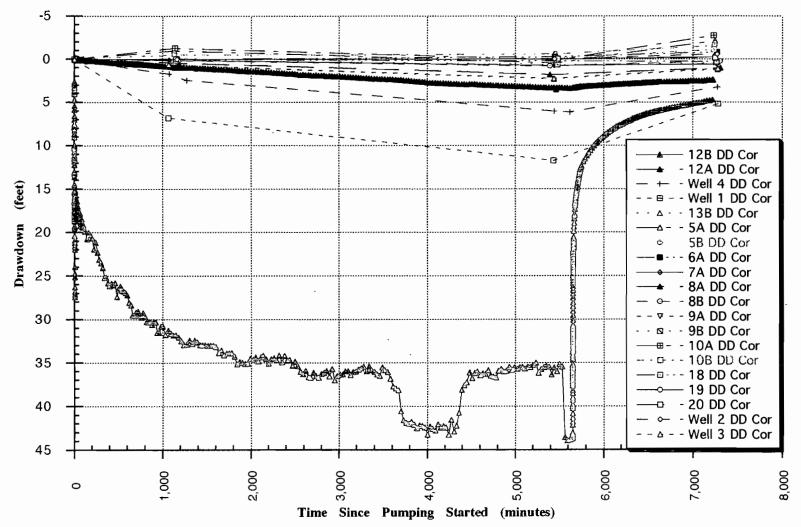
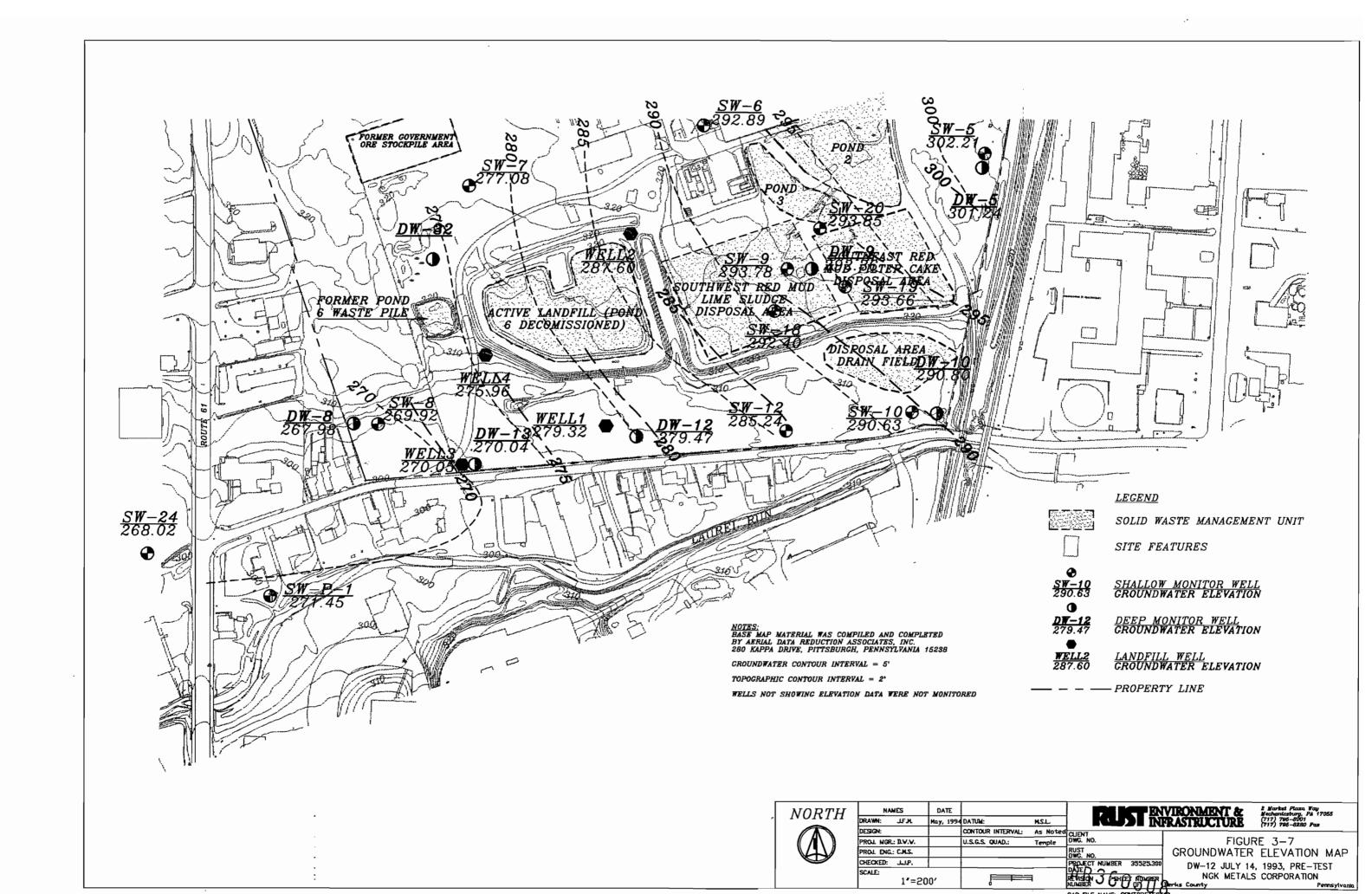
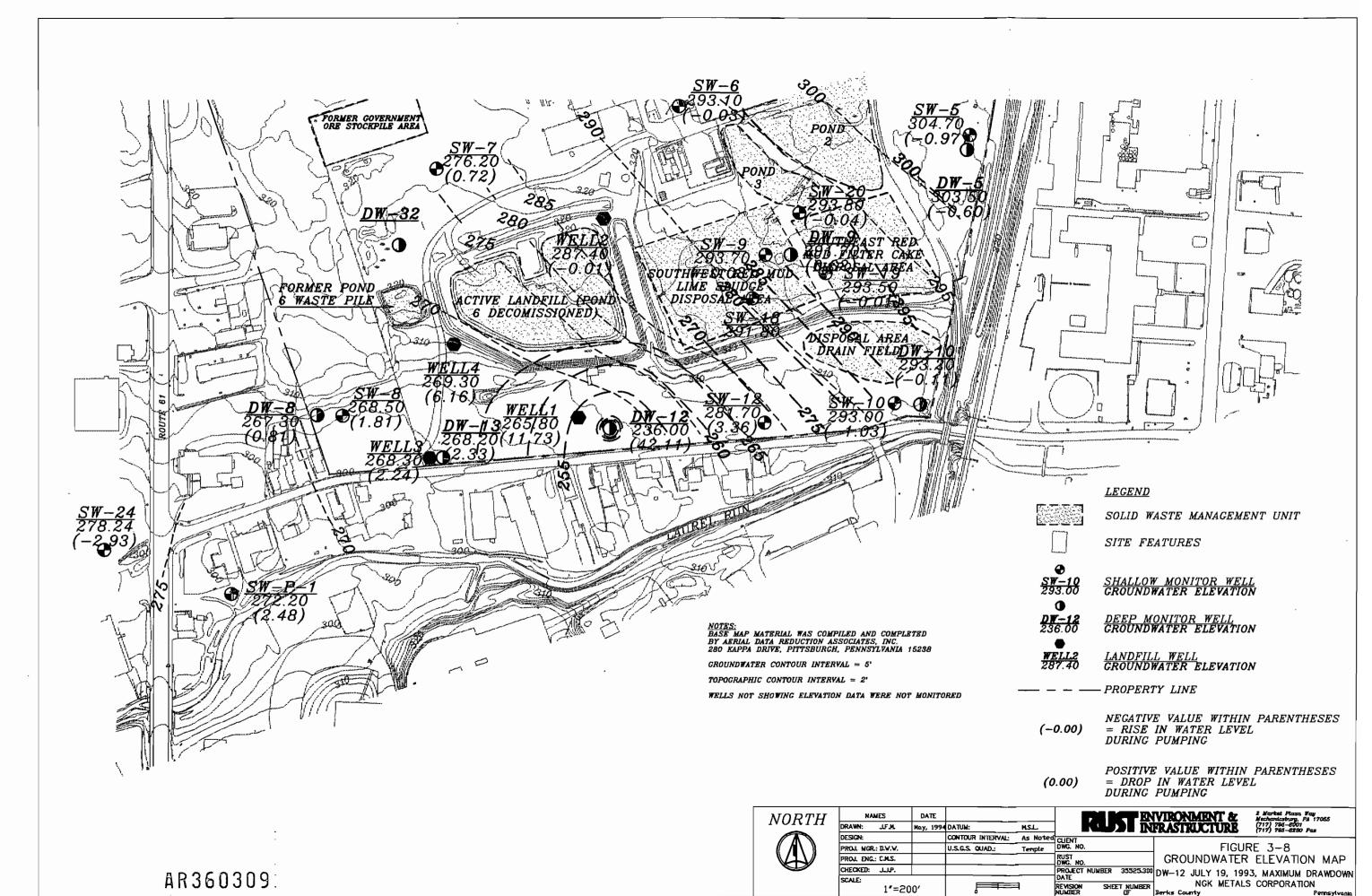


Figure 3-6
Drawdown/Recovery Test Graph
for Pumping Well MW-12B







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stopped. A significant rain event of 0.83 inches occurred on July 14, the day before the drawdown test began. Recorded water levels in observation wells monitored during the drawdown test do not appear to reflect this precipitation event. Another rain event of 1.07 inches occurred on July 18, which was the day before the pump was shut off. Water level recovery responses may have been enhanced due this storm event. Precipitation data are presented in Appendix D.

3.3.3 DW-13

Drawdown/recovery testing was performed on deep well DW-13 from June 14 to June 21, 1993. The drawdown test lasted approximately 9730 minutes at an average rate of 105 gpm. The total pumping time is estimated, since the pump was inadvertently shut off before the data logger could be immediately re-set to record groundwater recovery responses. The data logger was reset sufficiently early, however, to record water level recovery beginning within an estimated 30 minutes of pump shut off. Water level response graphs for the drawdown and recovery tests are shown in Figures 3-9 and 3-10. Well DW-13, like well DW-12, is a 6-inch diameter open bedrock well. The open bedrock interval is from 105 to 165 feet below ground. Four-inch diameter PVC screen was used to maintain borehole integrity during pumping to prevent potential bedrock formation collapse around the pump.

Because of limited space between the pump intake and the inner PVC screen surface, it is believed that groundwater flow was restricted during the drawdown test. As a result, recorded drawdown within the screen was enhanced due to well inefficiency. The maximum recorded drawdown in the pumped well was just slightly more than 38 feet. In adjacent shallow Well 3, located only about 15 feet away, the drawdown was approximately 19 feet. Therefore, the actual drawdown in DW-13 is between 19 feet and 38 feet, but probably closer to 19 feet.

Water levels in a total of six monitor wells dropped more than one foot, and was due to pumping of well DW-13. The water level in well SW-7 dropped less than one foot (0.85 feet), however, and this corrected drawdown is likely from pumping of DW-13. Recorded (corrected) drawdowns in shallow wells and deep wells are as follows:

TABLE 3-4
DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-13

DISTANCE FROM DW-13 (ft.)
0.25
15
250
264
265
327
391
620

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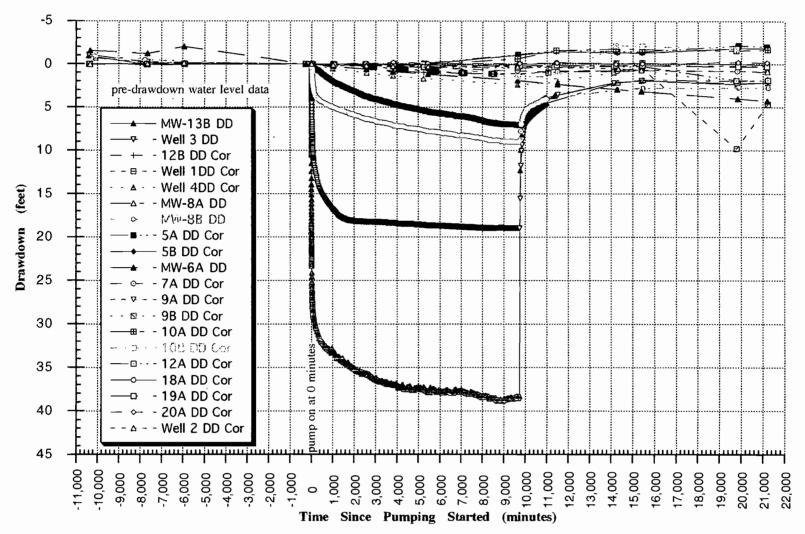


Figure 3-9
Pre-Test/Drawdown/Recovery Test Graph
for Pumping Well MW-13B

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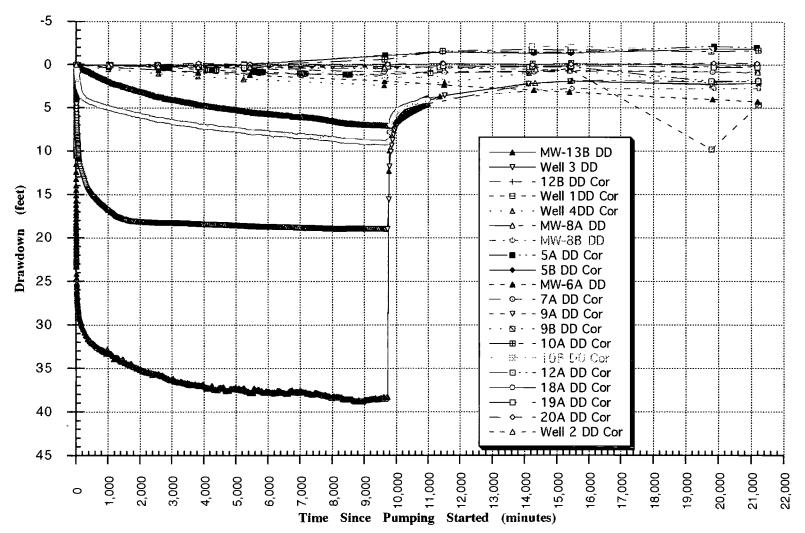
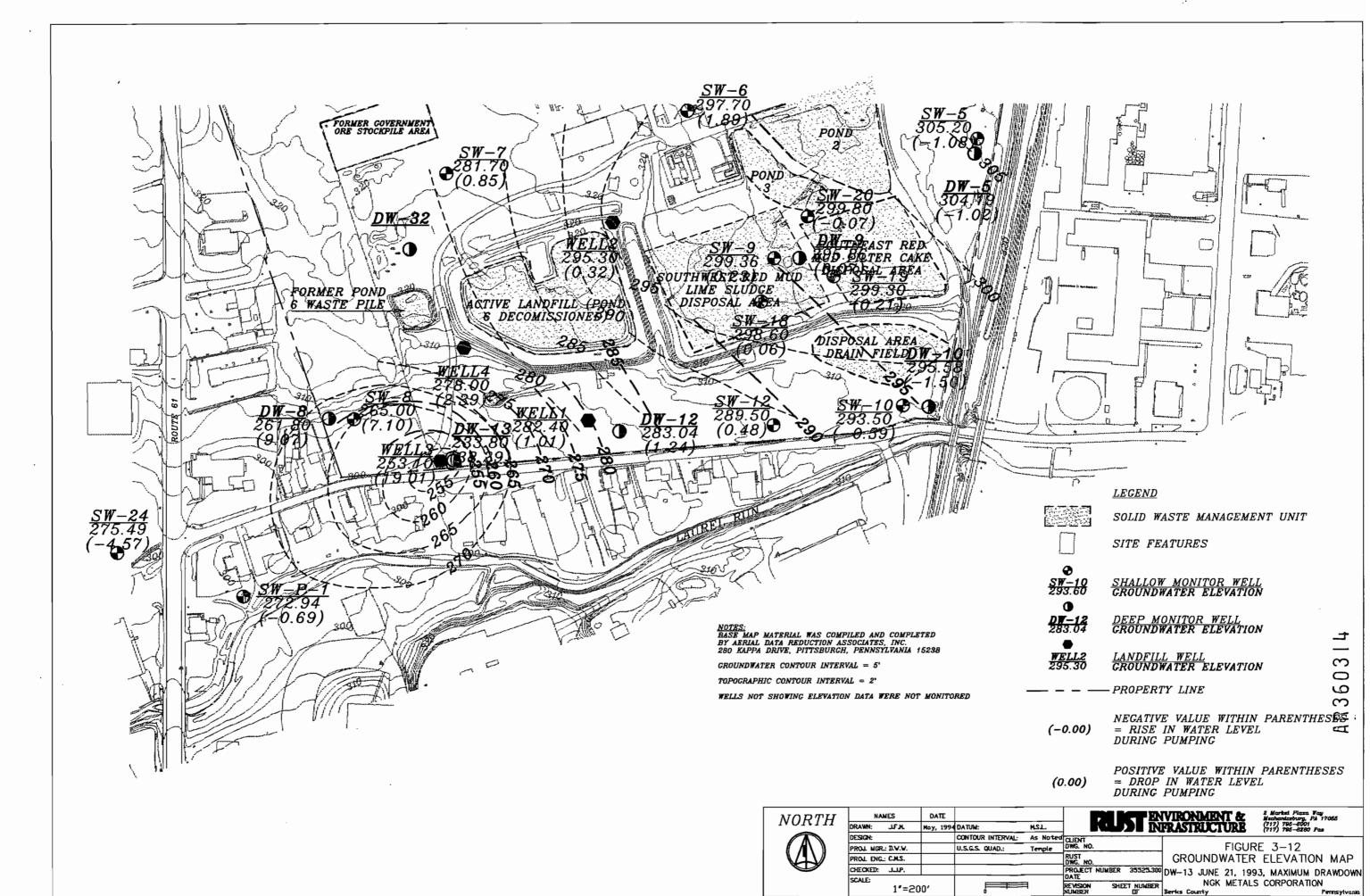


Figure 3-10
Drawdown/Recovery Test Graph
for Pumping Well MW-13B



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As expected, the nearest observation well to the pumping well, Well 3, exhibited the most drawdown, while respective drawdowns decreased with increasing depth away from the pumping well. Although, the data from well DW-12 suggest that it may be more effectively connected to deep well DW-13 than Well 1, which is slightly closer. Likewise, shallow well SW-8 is closer to DW-13, however, the recorded drawdown is nearly 2 feet less than in deep well DW-8, which is slightly further away. These data indicate that, in general, the hydraulic connection between wells within the deeper aquifer system in this portion of the site is apparently better than the shallow wells with the pumping (deep) well. Groundwater elevation data prior to pumping and at the time of maximum drawdown are shown on Figures 3-11 and 3-12, respectively.

Groundwater recovery responses were recorded immediately following the drawdown test. The water level in the well DW-13 achieved 95% recovery when the data logger was stopped.

3.3.4 DW-27

Deep well DW-27 was pump tested from March 28 to April 1, 1994. The drawdown test lasted approximately 5661 minutes or nearly four days. An initial pumping rate of approximately 90 gpm gradually reduced to 85 gpm over the length of the test. This drop was most likely due to pump inefficiency due to increased head (i.e. deeper water level within the pumping well).

Drawdown (uncorrected) in the pumping well reached nearly 33 feet. Drawdown was also observed in monitor wells SW-22, SW-23, DW-15 and DW-28. The most significant drawdown, more than 7 feet, occurred in well DW-28, which is approximately 160 feet away. Shallow well SW-23 experienced the next highest drawdown of slightly more than 3 feet. This well is about 325 feet from the pumping well. Nearly 2 feet of drawdown was measured in deep well DW-15, which is located roughly 300 feet away. The least amount of water level drop occurred in well SW-22, which is approximately 200 feet from DW-27. Drawdown data indicate a preferred orientation of the area of influence roughly trends west to east paralleling Tuckerton Road. Distance-drawdown data are summarized below in Table 3-5. Water level response graphs are shown on Figures 3-13 and 3-14. Pre-test and maximum drawdown groundwater elevation maps are presented on Figures 3-15 through 3-16.

TABLE 3-5

DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-27

<u>WELL</u>	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM DW-27 (ft.)
DW-27	32.84	0.33
DW-28	7.36	157
SW-22	0.28	202
DW-15	2.03	300
SW-23	3.06	325

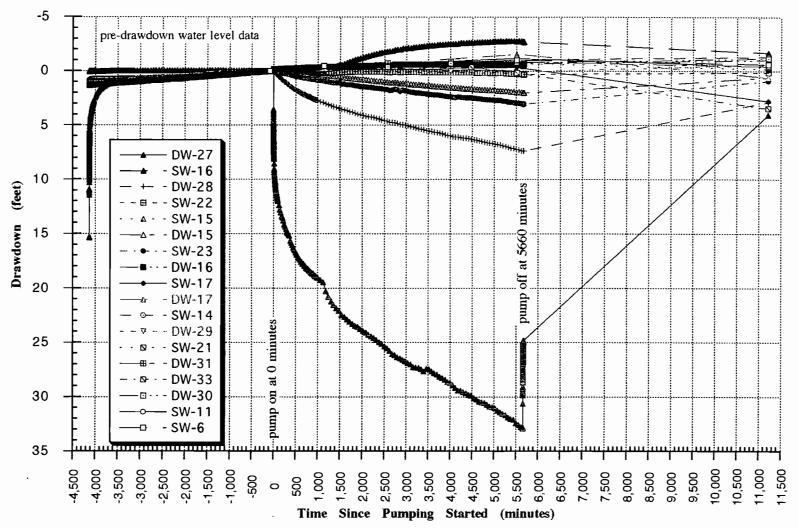


Figure 3-13
Pre-Test/Drawdown/Recovery Test Graph
for Pumping Well DW-27

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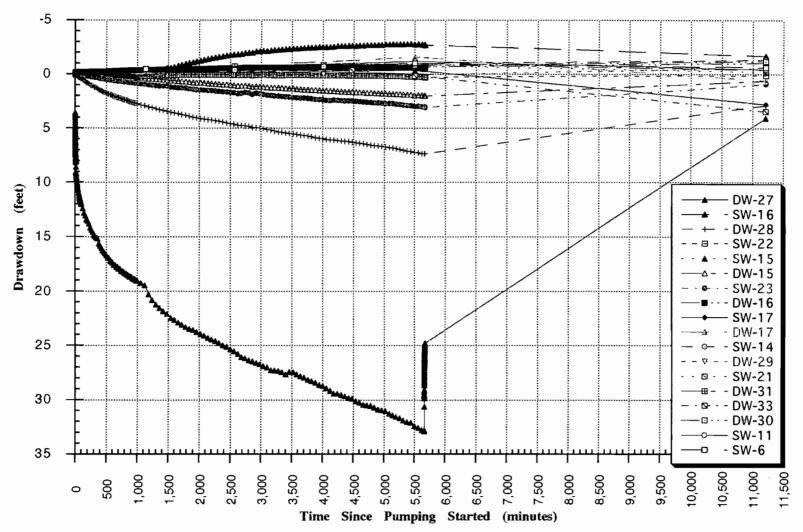
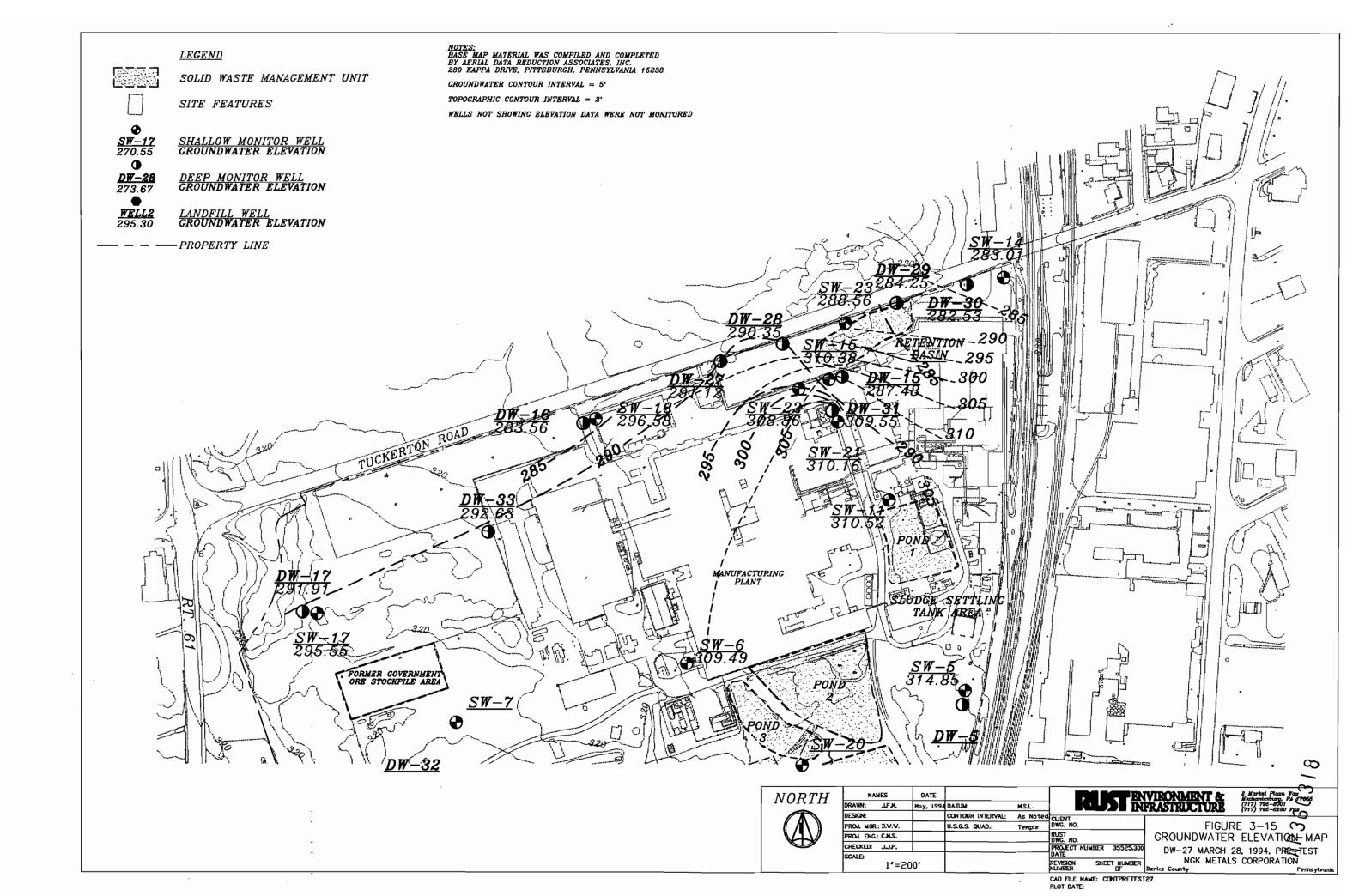
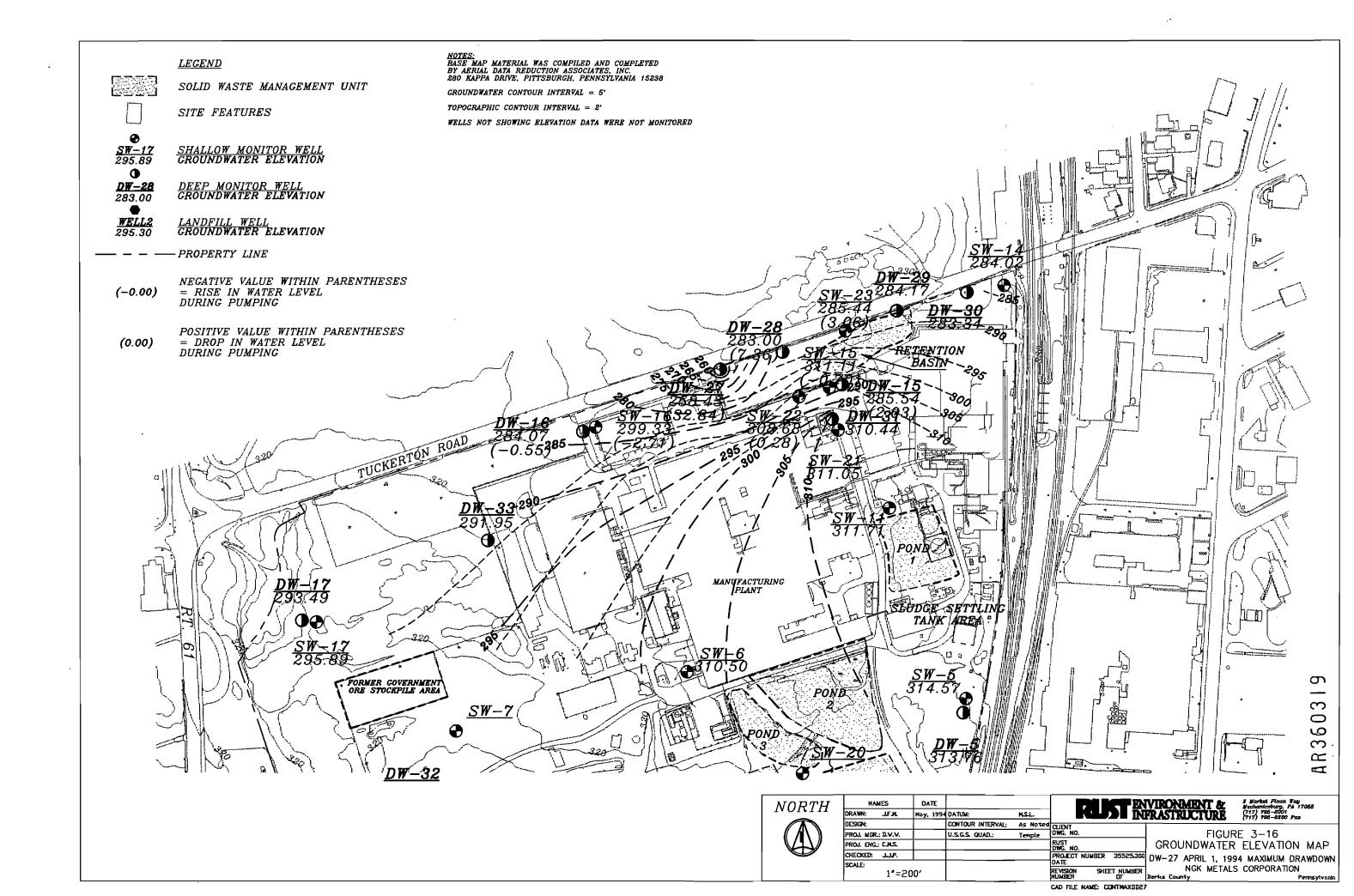


Figure 3-14 Drawdown/Recovery Test Graph for Pumping Well DW-27









Immediately following pump shut-off water level responses were recorded during the recovery period. Four days after the pump was shut off, well DW-27 achieved approximately 90% recovery.

3.3.5 DW-28

Drawdown/recovery testing of well DW-28 was performed from July 30 to August 3, 1993. The drawdown test lasted approximately 4025 minutes or nearly three days. An initial pumping rate of 8 gpm eventually dropped to approximately 4 gpm after about 1090 minutes. This decrease in pumping rate coincided with a water level decline to the pump intake. The pump test continued for roughly two more days at a sustained pumping rate of 4 gpm. Water level response graphs are presented on Figures 3-17 and 3-18.

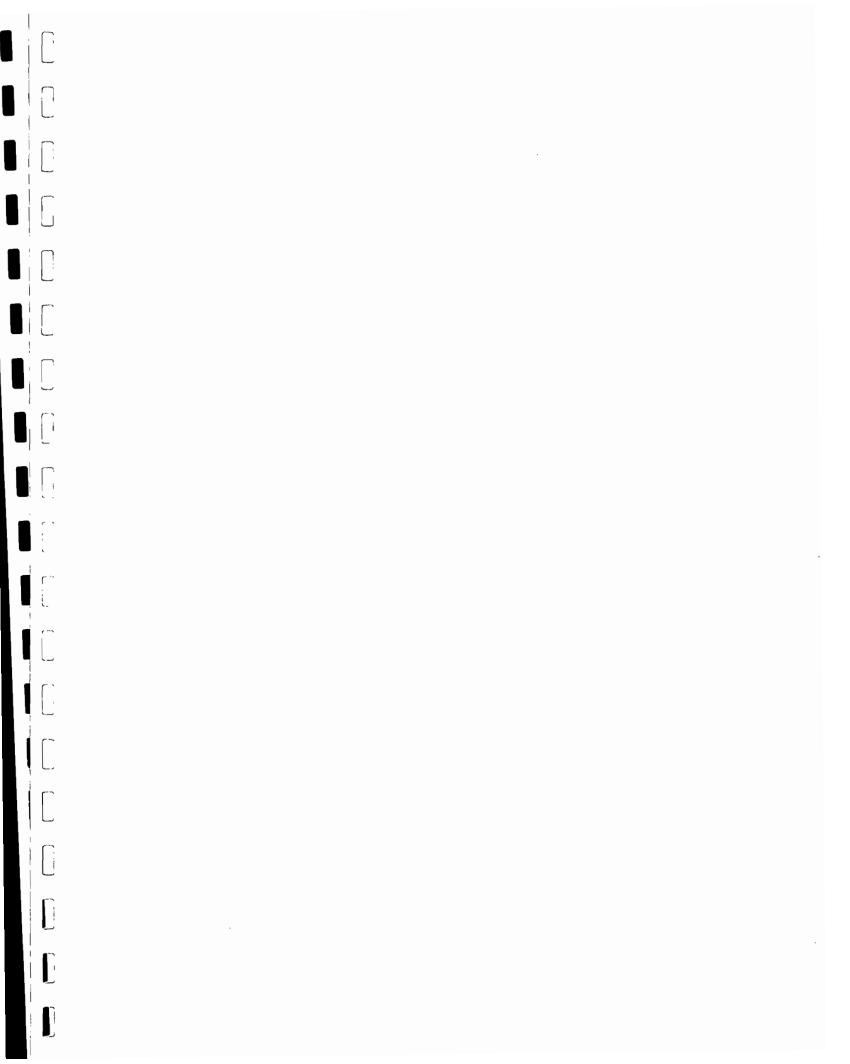
The pumping well reached a maximum drawdown of approximately 40 feet. This maximum drawdown is uncorrected due to impacts of the step-drawdown test to the pre-test water level trend. It is anticipated that corrections to the drawdown in the pumping well would be minor, and, therefore, represent an insignificant proportion of the total recorded drawdown.

Drawdown in well SW-21, about 233 feet from DW-28, was approximately 7 feet. Seven feet was the maximum drawdown observed in all monitored wells. Recorded drawdown in wells SW-23 and DW-31 were 0.91 and 0.80 feet, respectively. Shallow well SW-23 is about 162 feet from DW-28, while deep well DW-31 is about 203 feet away. Distance-drawdown data are summarized below.

TABLE 3-6
DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-28

WELL	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM DW-28 (ft.)
DW-28	40.40	0.33
SW-23	0.91	162
DW-31	0.80	203
SW-21	7.06	233

The sustained pumping of well DW-28 appears to have little impact on depressing the water level surface for both the shallow and deep aquifer systems over an extended area. There is, however, an apparent hydraulic connection between the pumping well and SW-21. It is possible that these two wells are connected to each other within the bulk aquifer by way of a conduit (i.e. solution channel). A void was encountered in well SW-21 from 26 to 30 feet, and in well DW-28 at 63 to 74 feet. Pre-test and maximum drawdown groundwater elevations are shown on Figures 3-19 and 3-20, respectively.



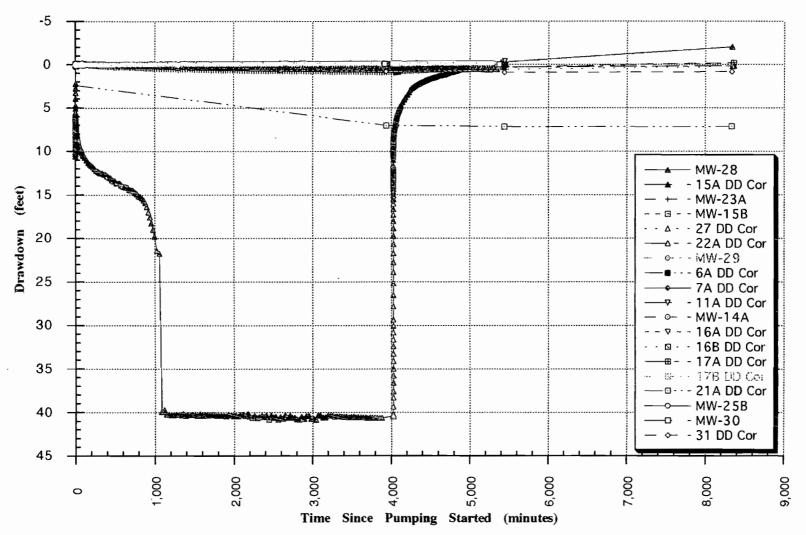
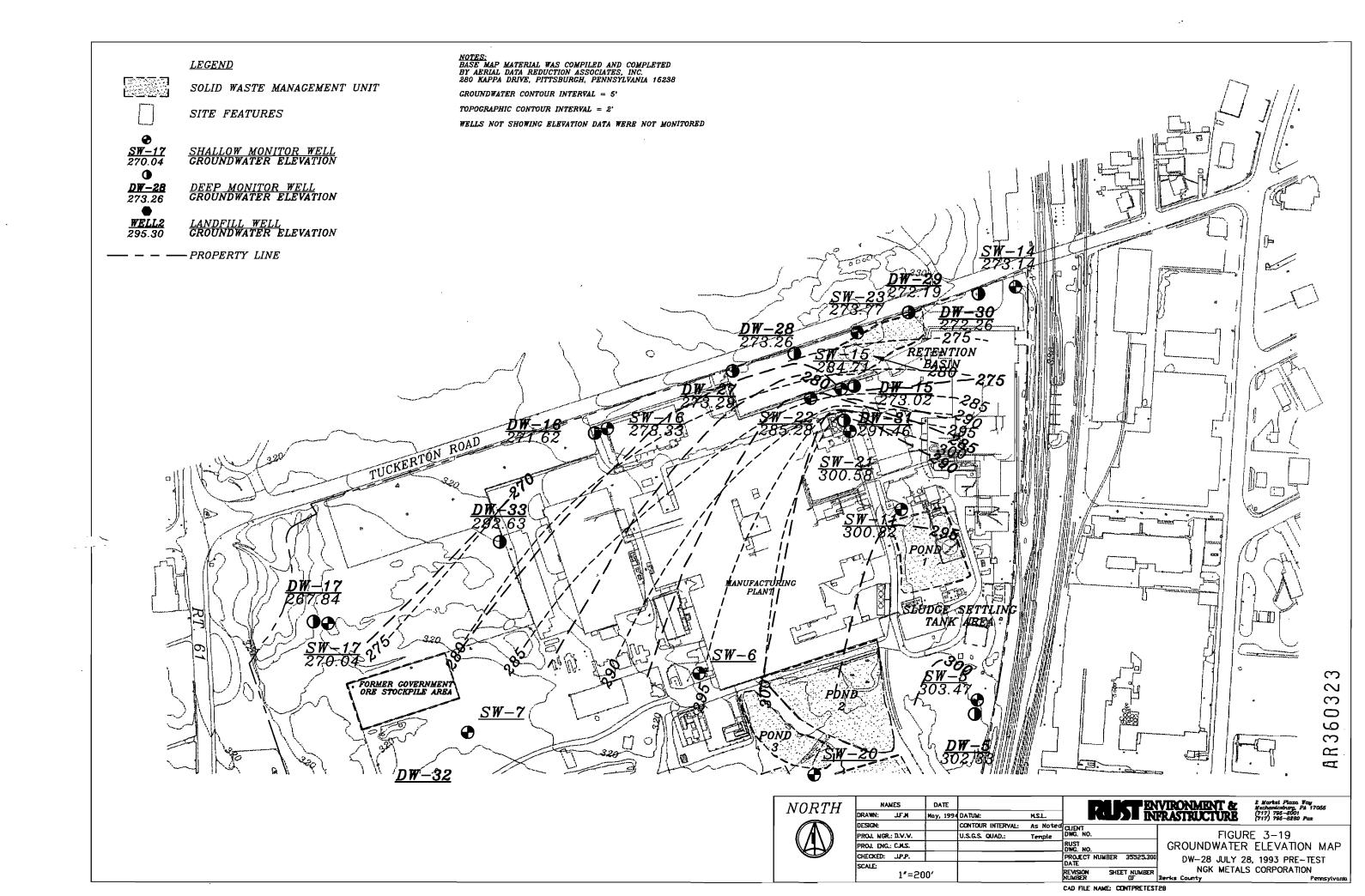


Figure 3-18
Drawdown/Recovery Test Graph
for Pumping Well MW-28



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A groundwater recovery test was performed immediately after the pump was shut off. The water level in well DW-28 achieved full recovery by the next day. The water level response plot of well DW-28 (see Figure 3-13) extends beyond zero drawdown indicating that the water level rose above the pre-test static water level.

3.3.6 DW-29

Deep well DW-29 was drawdown tested from July 23 to July 26, 1993 at an average pumping rate of approximately 87 gpm. The pumping rate was established initially at about 115 gpm, and eventually decreased to approximately 74 gpm. During the test the water level in the pumping well gradually dropped until it reached the pump intake. The well sustained a yield of 74 gpm despite the water reaching the pump intake. The well was pumped for a total of 3483 minutes, at which time the recovery test began. Total corrected drawdown in well DW-29 was slightly more than 41 feet. Water level responses to pumping well DW-29 are shown on Figures 3-21 and 3-22.

Drawdowns (corrected) of one or more feet were recorded in five of the monitored observation wells. These wells along with their respective corrected drawdowns and distances from the pumping well are summarized below.

TABLE 3-7
DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-29

<u>WELL</u>	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM DW-29 (ft.)
DW-29	41.28	0.42
SW-23	2.95	134
DW-30	3.66	176
DW-15	6.06	224
SW-14	2.58	270
DW-28	1.57	296

The water level in downgradient deep well DW-30 responded to pumping of DW-29 by dropping almost 4 feet. DW-30 is the nearest deep observation well to the pumping well. Upgradient well DW-15, which is the next closest deep well, showed the most significant dropping water level recorded at nearly 6 feet. The resultant drawdown in DW-15 indicates that the well is effectively connected to well DW-29 within the bulk aquifer. This connection is apparently along strike (bearing) of the underlying bedrock, which is reportedly N65°E in the area of the NGK site. This direction is roughly parallel to a line drawn through DW-15 and DW-29. Figure 3-23 shows pretest groundwater elevation data and maximum groundwater elevation data are presented on Figure 3-24.

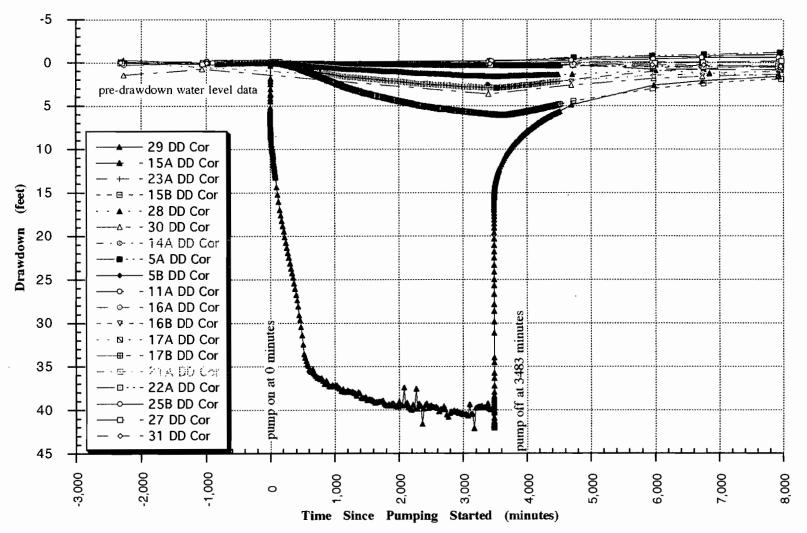


Figure 3-21 Pre-Test/Drawdown/Recovery Test Graph for Pumping Well MW-29

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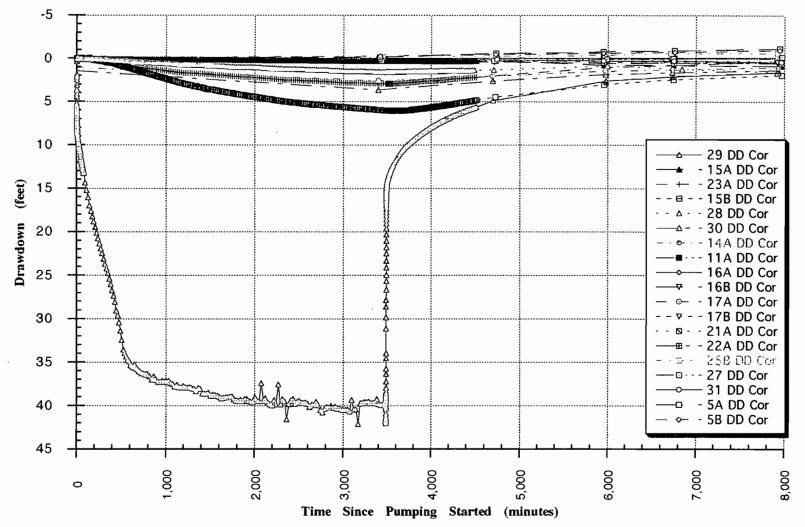
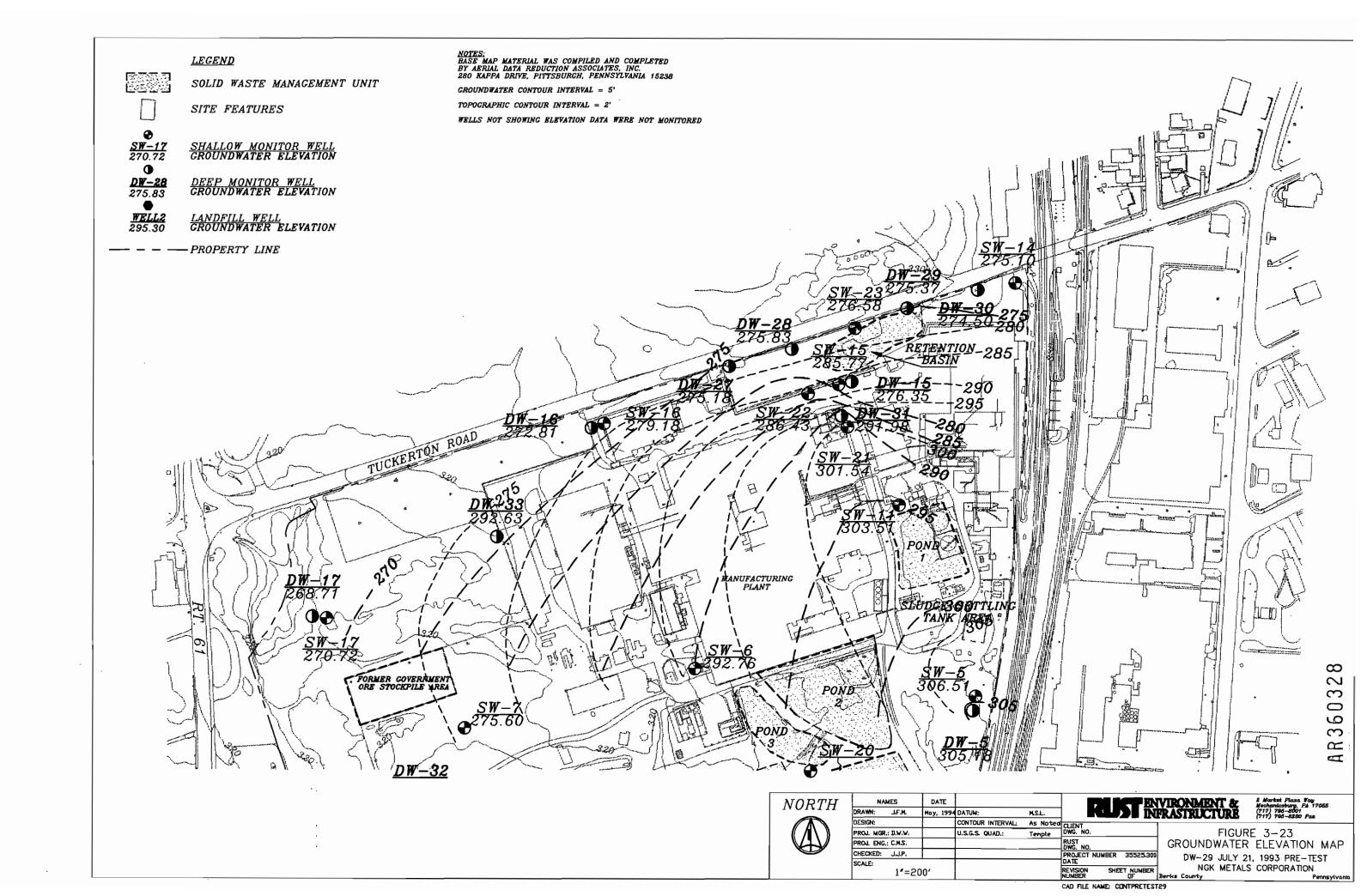
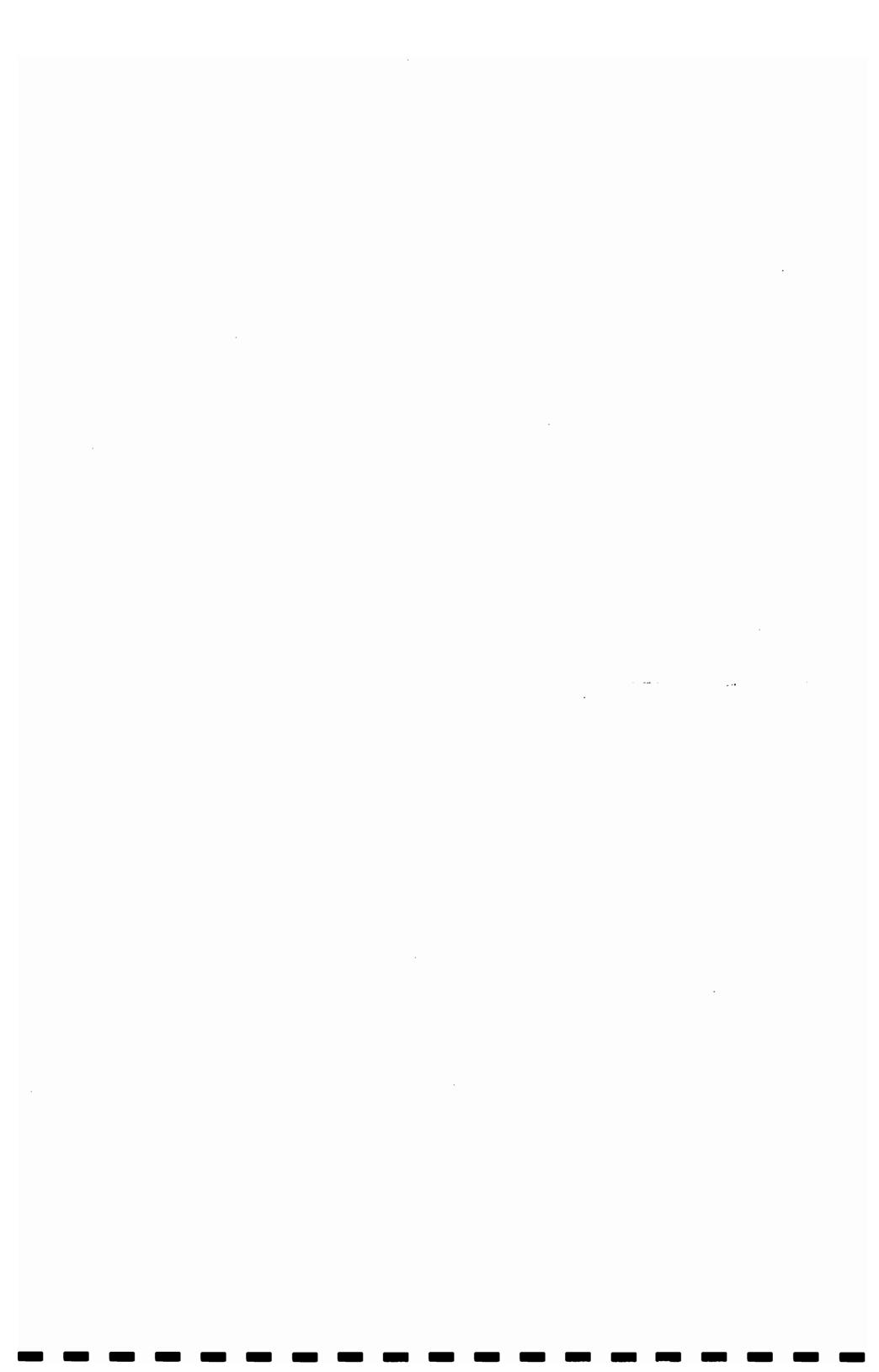
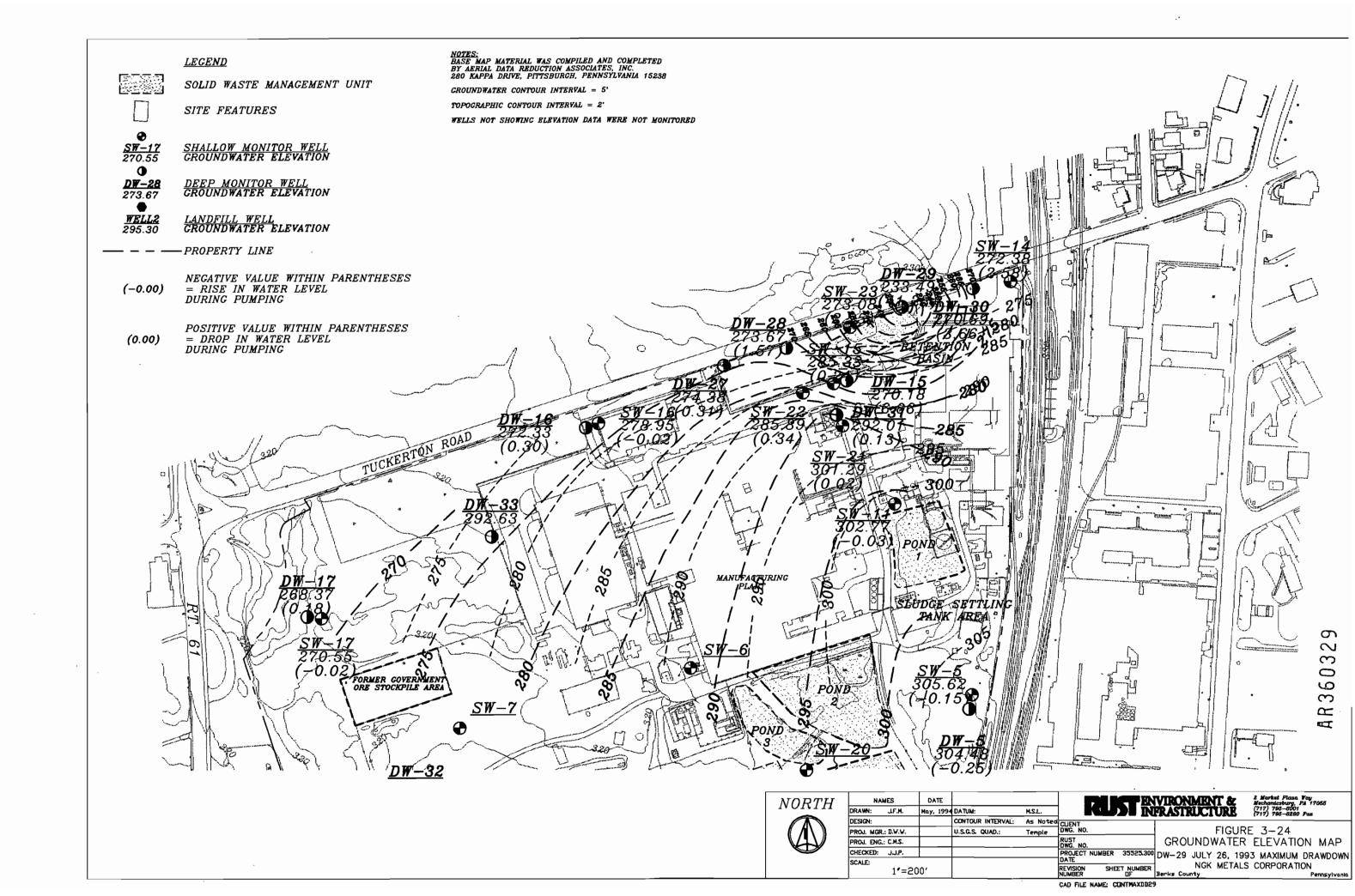


Figure 3-22
Drawdown/Recovery Test Graph
for Pumping Well MW-29

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After completion of the drawdown test, water level responses during the recovery period were recorded. The water level in pumping well DW-29 reached approximately 95% recovery prior to stoppage of the test. No precipitation events were reported during the recovery period that may have affected the water level responses.

3.3.7 DW-32

Drawdown/recovery testing was performed on well DW-32 from March 29 to April 2, 1994. The well was pumped, initially at a rate of 10 gpm, for 5776 minutes or approximately four days. The pumping rate dropped slightly to approximately 9 gpm during the test most likely due to pump inefficiency affected by an increase in hydraulic head (i.e. lower water level).

A total (uncorrected) drawdown of approximately 63 feet was achieved in well DW-32. The pumping water level appeared to reach equilibrium at a rate of 9 gpm. Well SW-7 exhibited the most drawdown in monitored observation wells. Here, more than two feet of drawdown occurred. The well is located approximately 200 feet from the pumping well. Drawdowns in monitor wells DW-13, SW-8, Well 2, Well 3, and Well 4 all were approximately 0.7 feet and may have been due to pumping. The water level response curves shown on Figures 3-25 and 3-26 indicate that well SW-7 mimics the drawdown curve for DW-32. Well 4 was impacted due to pumping because the rising water level leveled at the time pumping began. To a lesser extent, the water level in DW-8 showed a similar but delayed response. The responses wells DW-8 and Well 4 indicate that they both were impacted by pumping and naturally declining water levels.

The area of influence created by pumping well DW-32 appears to extend from at least shallow well SW-7 to Well 4 and towards deep well DW-8. Pre-test and maximum drawdown maps are shown on Figures 3-27 and 3-28. Distance-drawdown data are summarized below.

TABLE 3-8

DRAWDOWN AND DISTANCE SUMMARY
PUMPING WELL DW-32

<u>WELL</u>	<u>DRAWDOWN</u> (ft.)	DISTANCE FROM DW-32 (ft.)
DW-32	63.19	0.33
SW-7	2.28	200
Well 4	0.77	263
SW-8	0.62	420
Well 2	0.76	478
DW-13	0.71	500
Well 3	0.70	502

Water level recovery data were recorded immediately following pump shut off. The water level in well DW-32 reached approximately 93% recovery when data logging was terminated.

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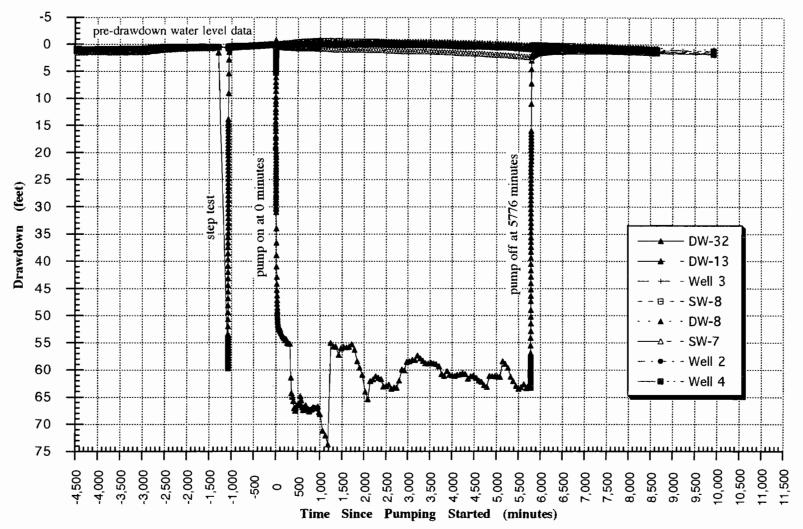


Figure 3-25
Pre-Test/Drawdown/Recovery Test Graph
for Pumping Well DW-32

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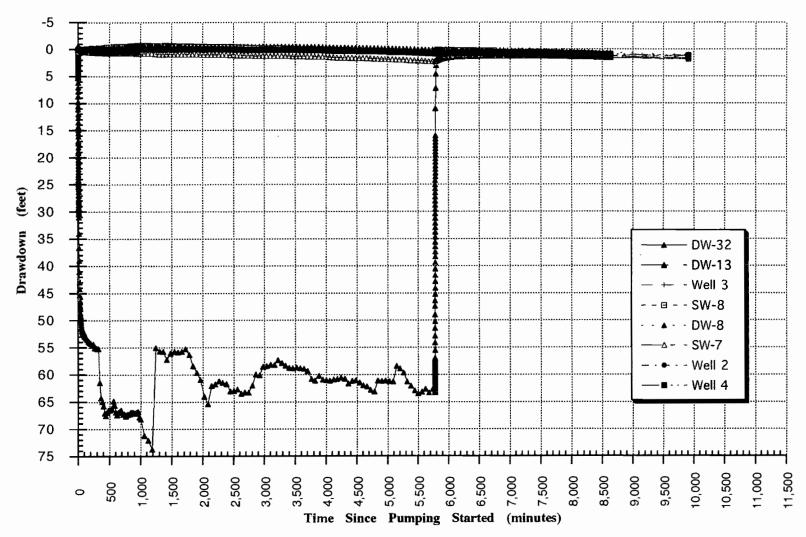
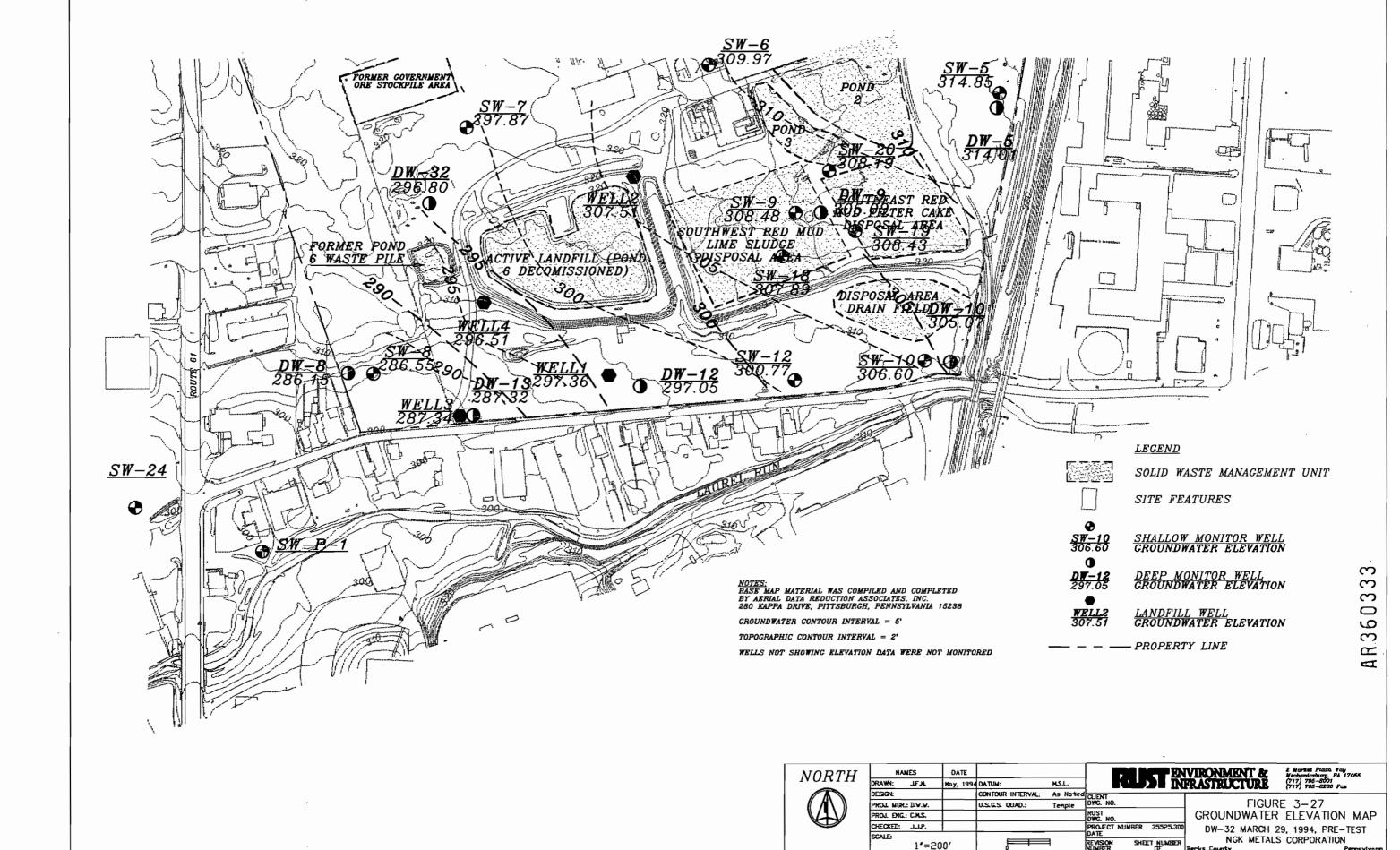
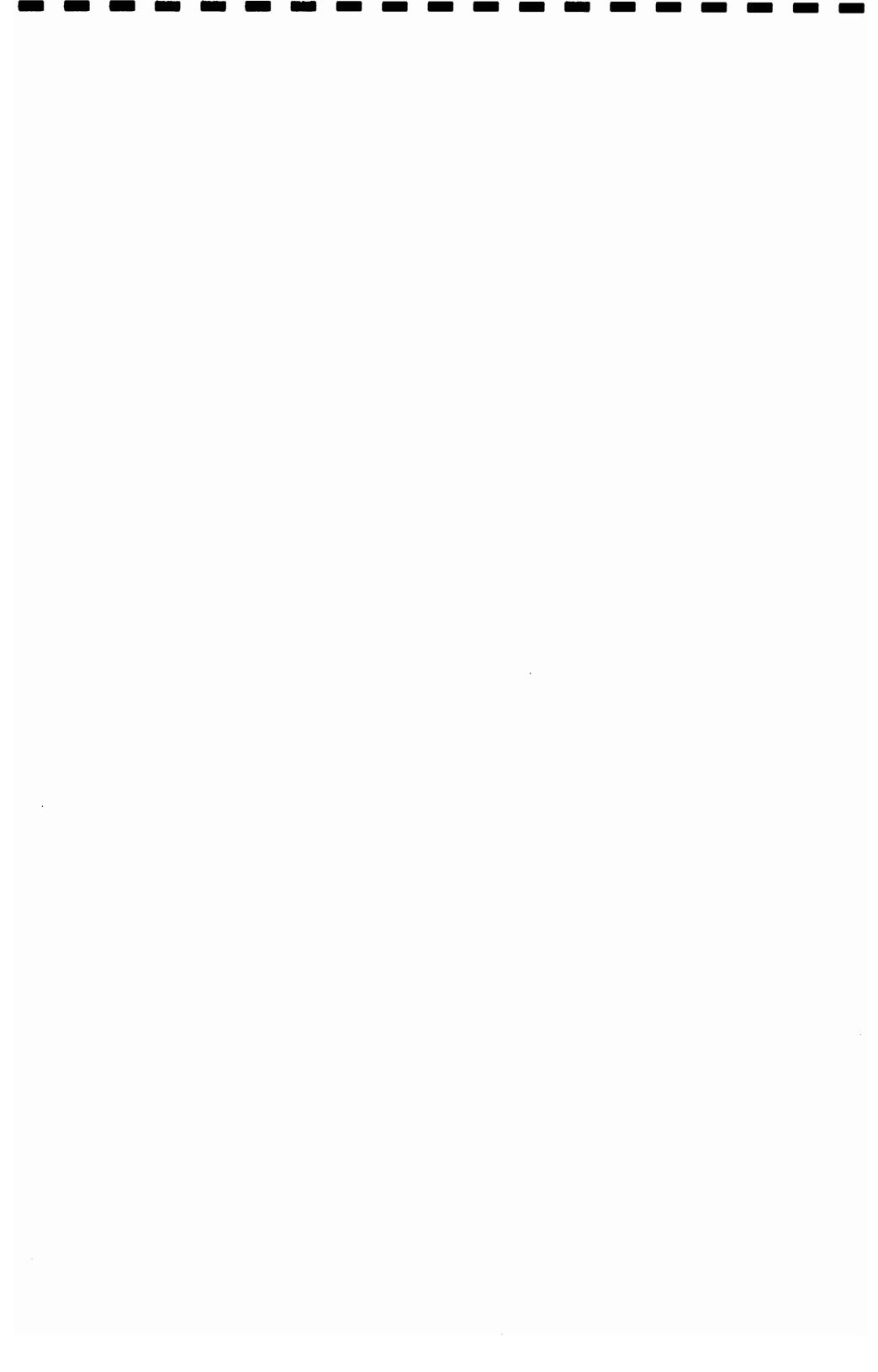
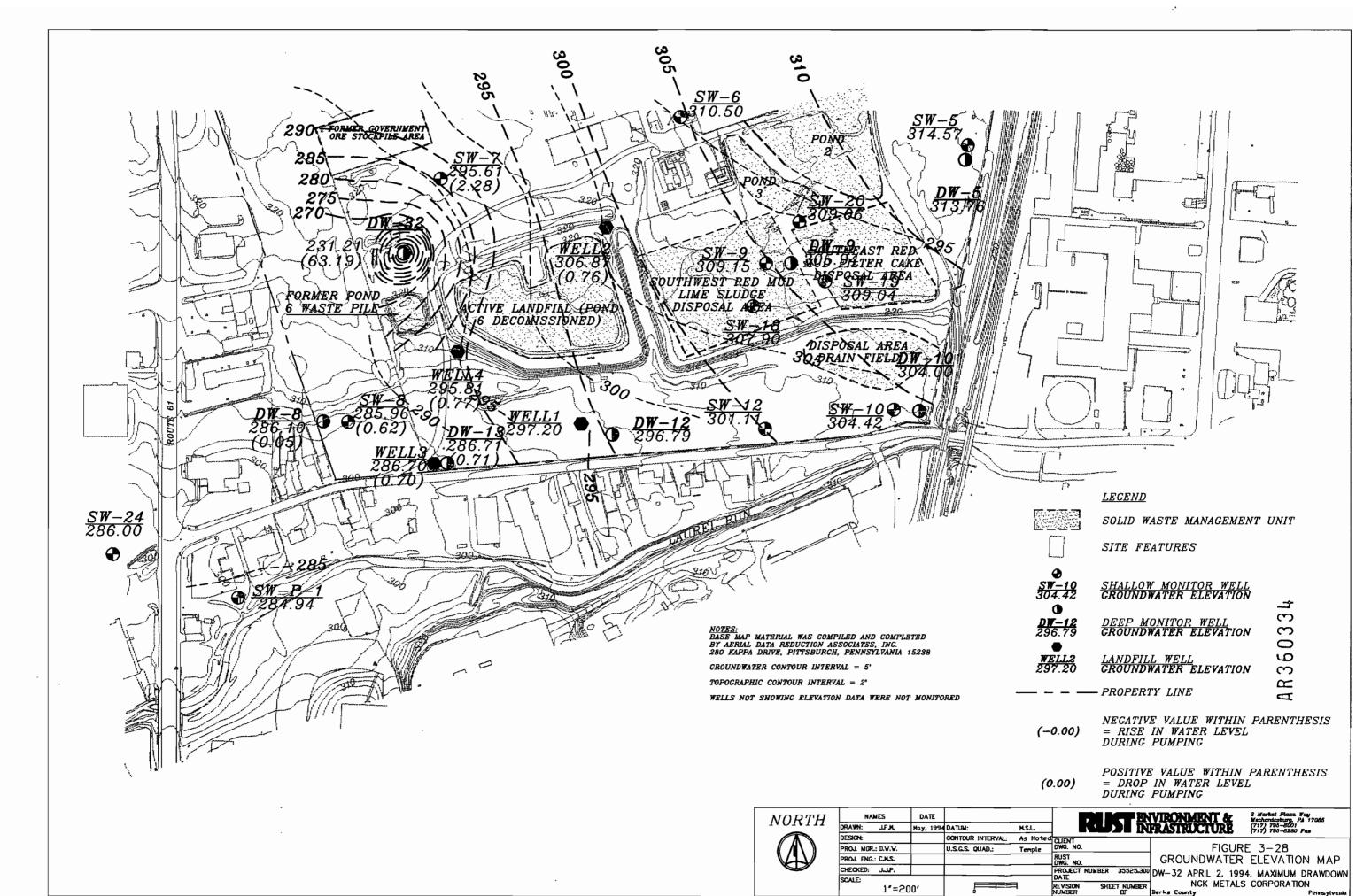


Figure 3-26 Drawdown/Recovery Test Graph for Pumping Well DW-32

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4.0 GROUNDWATER CHEMISTRY

4.1 INTRODUCTION

During each of the respective drawdown tests, groundwater samples were collected on regular intervals and submitted to Lancaster Laboratories for analysis. Analytical testing was conducted on each groundwater sample to provide well-specific chemistry data. These data were analyzed and evaluated to establish trends in chemical concentrations as a function of increased pumping time. The samples were analyzed for the following site-specific and general parameters:

TABLE 4-1 ANALYTICAL PARAMETERS FOR PUMP TESTS

Site-Specific Parameters

Beryllium (total)

Cadmium (total)

Chromium (total)

Copper (total)

Fluoride

Purgeable Halocarbons

Purgeable Aromatics

General Parameters

Total Suspended Solids (TSS)
Total Dissolved Solids (TDS)

Total Hardness

Iron (total)

Nitrate-Nitrogen*

Sulfate*

Field Parameters

Temperature

Specific Conductivity

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In addition, new deep wells DW-27, DW-30, DW-32 and DW-33 were sampled to characterize groundwater quality in the area of these respective wells. Groundwater samples were analyzed for those parameters summarized above along with Priority Pollutant Metals, chloride, sulfate and nitrate-nitrogen. These data are presented in Table 4-2. These parameters were selected based on water quality characteristics needed to conduct pilot scale tests to determine the effectiveness of a proposed water treatment system. New deep well DW-31 was not sampled due to low well yield.

4.2 ANALYTICAL RESULTS

Groundwater samples were collected during each of the individual drawdown tests on a daily basis, whenever possible. The total number of samples per well depended on the duration of each drawdown test.

^{*} Nitrate-Nitrogen and Sulfate were analyzed only for wells DW-27 and DW-32

TABLE 4-2 NGK METALS NEW WELLS

WELL	DW-27	DW-30	DW-32	DW-33
LAB PARAMETER	_			
(mg/l)				
TSS	47	10	296	109
TDS	990	800	840	410
Total Hardness	657	402	314	273
Chloride	110	45	NA	NA
Fluoride	4.8	9.4	15	2.1
Sulfate	310	290	NA	NA
Nitrate-Nitrogen	19	8.4	NA	NA
LAB PARAMETER				
(mg/l)				
Arsenic	0.0028	<0.0020	NA	NA
Mercury	< 0.00020	<0.00020	NA	NA
Selenium	< 0.0020	<0.0020	NA	NA
Thallium	< 0.30	<0.30	NA	NA
Antimony	< 0.20	<0.20	NA	NA
Beryllium	0.100	<0.010	0.025	< 0.010
Cadmium	< 0.010	< 0.010	<0.010	<0.010
Chromium	0.404	< 0.050	0.051	0.048
Copper	0.088	<0.020	0.05	< 0.025
Iron	3.40	1.21	31.10	7.47
Lead	< 0.10	<0.10	NA	NA
Nickel	< 0.050	<0.050	NA	NA
Silver	< 0.020	< 0.020	NA	NA
Zinc	<0.040	<0.040	NA	NA
LAB PARAMETER				
(μg/l)				
1,2-DCE (cis/trans)	<1	3	1	<1
1,1-DCE	<1	<1	29	5
1,1-DCA	<1	<1	30	1
1,1,1-TCA	7	2	46	2
TCE	1	<1	5	2
PCE	<1	<1	<1	18
FIELD				
PARAMETER				
Temperature (;C)	NA	14.7	NA	NA
Specific Conductivity	1.56	0.985	0.840	0.460
(mU/cm)				
pH (Standard units)	NA	7.20	7.12	7.17
Turbidity (NTU)	<200	25.1	NA	NA

NA=Not Available/Analyzed

TABLE 4-3 NGK METALS PUMP TESTS CHEMICAL DATA SUMMARY

WELL		MW	′-8A					MW-12B		
SAMPLE NO.	MW-8A-1	MW-8A-2	MW-8A-3	MW-8A-4	MW-12B-1	MW-12B-2	MW-12B-3	MW-12B-1 (1)	MW-12B-2 (1)	MW-12B-3 (1)
LAR BARANCTER (
LAB PARAMETER (mg/l) TSS	45	24	<7	<7	6400	201	12.4	2020	200	2.7
TDS							134	3020	280	37
	690	550	550	580	910	740	730	870	740	760
Total Hardness	137	123	125	125	281	62	64	161	64	64
Fluoride	23.6	18.6	18.8	19.5	81.0	45.1	47.2	65.3	43.4	45.7
Sulfate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nitrate-Nitrogen	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
LAB PARAMETER (mg/l)										
Beryllium	0.019	0.015	0.014	0.014	0.334	0.022	0.023	0.230	0.036	0.024
Cadmium	<0.005	< 0.010	<0.010	< 0.010	0.076	< 0.010	< 0.010	0.022	< 0.010	< 0.010
Chromium	0.353	0.349	0.331	0.326	0.610	0.235	0.236	0.527	0.295	0.269
Copper	<0.025	<0.02	< 0.02	<0.020	0.510	<0.020	0.028	0.546	0.107	0.064
Iron	3.33	1.24	0.15	0.11	518	7.22	8.74	401	20.5	4.18
LAB PARAMETER (µg/i)										
Methylene Chloride	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
1,2-DCE (cis/trans)	<1	<1	<1	<1	<1	<1	<1	<1	<1 <1	<1 <1
1,1-DCE	19	10	10	9	<1	1	2	<1	4	3
1,1-DCA	7	4	5	4	<1	2	2	2	2	2
1,1,1-TCA	65	35	34	33	<1	9	12	5	16	15
1,1,2-TCA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
TCE	2	2	1	1	3	2	2	3	2	2
PCE	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
FIELD PARAMETER		100								
Temperature (°C)	13.3	13.9	13.3	14.4	14.8	NA	14.1	14.8	13.9	13.3
Specific Conductivity (mU/cm)	0.864	0.750	0.696	0.567	1.495	NA	1.029	1.421	1.236	1.120
pH (Standard units)	7.13	7.44	7.12	6.81	8.91	NA	7.76	8.81	7.89	8.11

Notes: (1) Samples MW-12B-1 and 12B-2 are duplicated due to aborted pump test

⁽²⁾ Sample MW-13B-1 was duplicated due to aborted pump test

⁽³⁾ Samples were diluted due to high levels of analyte

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TABLE 4-3 (cont.)
NGK METALS PUMP TESTS
CHEMICAL DATA SUMMARY

WELL			MW-1	3B					DW-27		
SAMPLE NO.	MW-13B-1	MW-13B-1 (2)	MW-13B-2	MW-13B-3	MW-13B-4	MW-13B-5	DW-27-1	DW-27-2	DW-27-3 (3)	DW-27-4	DW-27-5
LAB PARAMETER (mg/l)											
TSS	410	390	8	<7	<7	<7	650	23	<5	12	31
TDS	1020	1140	730	710	680	680	1040	880	890	890	940
Total Hardness	172	253	158	141	162	162	757	570	551	626	570
Fluoride	29.2	21.2	18.7	18.4	17.6	17.5	5.6	6.0	6.3	6.5	6.9
Sulfate	NA	NA	NA	NA	NA	NA	320	270	280	290	300
Nitrate-Nitrogen	NA	NA	NA	NA	NA	NA	21	18	17	16	16
LAB PARAMETER (mg/l)											
Beryllium	< 0.01	< 0.01	< 0.01	0.01	0.010	0.010	0.141	0.143	0.146	0.153	0.188
Cadmium	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.012	< 0.010	< 0.010	< 0.010	0.011
Chromium	0.790	1.09	0.45	0.40	0.38	0.37	0.641	0.752	0.798	0.843	0.954
Copper	0.030	0.03	< 0.02	< 0.02	< 0.02	< 0.02	0.699	0.170	0.205	0.206	0.238
Iron	31.0	39.0	0.6	0.3	0.1	0.1	41.4	1.55	0.40	0.61	1.43
LAB PARAMETER (µg/l)	_	_									
Methylene Chloride	<1	<1	<1	<l< th=""><th><1</th><th><1</th><th><1</th><th><1</th><th><10</th><th><1</th><th><1</th></l<>	<1	<1	<1	<1	<10	<1	<1
1,2-DCE (cis/trans)	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1
1,1-DCE	2	8	10	11	11	11	1	1	<10	<1	1
1,1-DCA	4	5	5	6	6	7	<1	<1	<10	<1	<1
1,1,1-TCA	16	41	43	58	61	62	6	6	<10	6	6
1,1,2-TCA	<1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1
TCE	1	1	2	. 2	2	2	1	2	<10	3	4
PCE	<1	<1	<1	<1	<1	<1	1	1	<10	1	1
FIELD PARAMETER											
Temperature (°C)	NA	11	11	10	12.4	12.6	14.4	15.3	16.9	16.6	16.6
Specific Conductivity (mU/cm)	1.459	1.498	0.733	1.167	1.117	1.117	1.314	1.098	2.00	1.144	1.174
pH (Standard units)	7.86	7.98	7.70	7.50	7.48	7.43	6.44	6.47	6.69	6.48	6.58

Notes: (1) Samples MW-12B-1 and 12B-2 are duplicated due to aborted pump test

⁽²⁾ Sample MW-13B-1 was duplicated due to aborted pump test

⁽³⁾ Samples were diluted due to high levels of analyte

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TABLE 4-3 (cont.)
NGK METALS PUMP TESTS
CHEMICAL DATA SUMMARY

WELL	MV	V-28	MV	V-29			DW-32		
SAMPLE NO.	MW-28-1	MW-28-2	MW-29-1	MW-29-2	DW-32-1	DW-32-2	DW-32-3 (3)	DW-32-4	DW-32-5
Y AN DAD AN COURT ((C)									
LAB PARAMETER (mg/l)		_	•••	_					_
TSS	1010	<7	290	<7	330	14	15	11	<5
TDS	1070	1020	740	810	850	870	900	920	920
Total Hardness	695	685	404	422	355	374	439	467	310
Fluoride		2.5	21.6	17.7	14	10	12	11	11
Sulfate	_	NA	NA	NA	300	310	310	310	310
Nitrate-Nitrogen	NA	NA	NA	NA	6.7	10.8	11	12	12
LAB PARAMETER (mg/l)									
Beryllium		< 0.010	0.480	0.360	0.082	0.053	0.052	0.055	0.054
Cadmium	< 0.010	< 0.010	0.016	0.011	< 0.010	0.014	< 0.010	<0.010	< 0.010
Chromium	_	< 0.050	4.48	0.590	0.116	0.168	0.127	0.132	0.131
Copper		<0.020	5.96	1.07	0.131	0.223	0.087	0.086	0.094
Iron	54.0	0.34	22.2	0.48	19.1	1.87	0.73	0.95	0.37
I AD DADAMETED (d)									
LAB PARAMETER (µg/l)							•		•
Methylene Chloride		<1	<1	1	<1	<1	<2	<1	<2
1,2-DCE (cis/trans)		<1	6	7	3	2	<2	2	<2
1,1-DCE	<1	<1	<1	<1	49	47	47	57	53
1,1-DCA	2	<1 2	<i< th=""><th><1</th><th>26</th><th>23</th><th>25</th><th>26</th><th>24</th></i<>	<1	26	23	25	26	24
1,1,1-TCA	4	3	3	5	130	160	220	210	200
1,1,2-TCA	<1	<1	<1	<1	1	<2	<2	<1	<2
TCE PCE	<1	<1	<1	1	13	10	11	11	10
PCE	<1	<1	2	3	1	1	<2	2	<2
FIELD PARAMETER									
Temperature (°C)	17.8	16.7	17.8	17.5	12.9	14.0	14.3	14.3	14.7
Specific Conductivity (mU/cm)	1.709	1.626	1.17	1.27	1.029	1.074	1.096	1.120	1.136
pH (Standard units)	6.31	7.14	6.39	5.74	6.74	6.82	6.81	6.76	6.89

Notes: (1) Samples MW-12B-1 and 12B-2 are duplicated due to aborted pump test

⁽²⁾ Sample MW-13B-1 was duplicated due to aborted pump test

⁽³⁾ Samples were diluted due to high levels of analyte

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4.2.1 SW-8

A total of four samples were collected for the test on well SW-8. As shown in Table 4-3, most parameters generally decreased in value or concentration with increased pumping. Beryllium, cadmium, chromium and copper concentrations either slightly decreased or remained relatively unchanged. Total iron decreased from 3.33 to 0.11mg/l.

The remaining inorganic parameters, total hardness, TSS, TDS, and fluoride, decreased in concentration.

The volatile organic compounds that were detected either decreased in concentration or remain unchanged. DCE, DCA, TCA and TCE were detected in concentrations above the detection limits and decreased slightly with increased pumping time.

Temperature, specific conductivity and pH were measured in the field at the time of groundwater sample collection. Specific conductivity and pH decreased, but the temperature increased slightly. The last pH reading indicates groundwater is slightly more acidic than would be expected for a carbonate (e.g. limestone or dolomite) aquifer. The heat generated from the pump motor most likely warmed up the groundwater slightly since the water level was near the pump intake. The chemical data are summarized in Table 4-3.

4.2.2 DW-12

A total of six groundwater samples were collected from deep well DW-12. Analytical data from three samples collected during an aborted drawdown test, and three samples during a successful test are presented in Table 4-3. The data from each of the respective tests correlate reasonably well with respective inorganic concentrations generally decreasing. Total beryllium, cadmium, chromium, copper and iron were all initially detected at levels higher than at the end of each test. Total beryllium levels ranged from 0.022 to 0.334 mg/l. Cadmium concentrations dropped to below the detection limits in the second and third samples from both tests. Total chromium levels decreased from 0.610 and 0.527 to 0.236 and 0.269 mg/l, respectively. Total iron concentrations improved not only within each of the tests, but also from the beginning of the first test through the end of the second test. An initial concentration of 518 mg/l ultimately decreased to 4.18 mg/l Purged groundwater from this well has historically been slightly to moderately turbid. Clay and silt particulates account for this turbidity, and are most likely emanating from the mud and clay filled void encountered from approximately 155 to 160 feet.

Fluoride and TDS concentrations generally decreased slightly, while TSS and total hardness decreased significantly with time. Fluoride values ranged from 43.4 - 81.0 mg/l. TDS ranged from 730 - 910 mg/l.

DCE, DCA, TCA and TCE were detected in concentrations above the detection limits and remained relatively unchanged with increased pumping time.

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Temperature, specific conductivity and pH decreased from the beginning to the end of the drawdown test. Temperature and pH appear within the typical range of groundwater in a carbonate aquifer in this area.

4.2.3 DW-13

Analytical data from six groundwater samples collected during two separate drawdown tests in deep well DW-13 are shown on Table 4-3. The initial samples were duplicated due to an aborted pump test. The remaining five samples were collected over a four day period. This discussion focuses only on the second drawdown test since there are insufficient data from the first test to identify water quality trends.

Total beryllium concentrations were below detection limits for the first and second sample, while the remaining three samples showed concentrations at the detection limit. Total cadmium was not detected in any sample. Total chromium concentrations decreased from 1.09 to 0.37 mg/l. Total copper was initially detected at 0.03 mg/l with the remaining samples below the detection limit. Total iron levels decreased significantly from 39.0 to 0.1 mg/l.

Fluoride and TDS decreased slightly over time, while TSS improved from 390 to <7 mg/l (detection limit). Fluoride varied from 17.5 to 29.2 mg/l and TDS ranged from 680 to 1020 mg/l.

DCE, DCA, TCA and TCE were detected in concentrations above the detection limits and generally increased slightly over time.

Temperature increased slightly, and specific conductivity and pH decreased slightly. Temperature and pH are within the typical range of anticipated values.

4.2.4 DW-27

A total of five groundwater samples were collected during the four days of pumping DW-27. Total beryllium concentrations increased only slightly from 0.141 mg/l to 0.188 mg/l. Total cadmium remained unchanged. Total chromium increased gradually from 0.641 mg/l to 0.954 mg/l. Total copper decreased from 0.699 mg/l to 0.238 mg/l. Total iron concentrations dropped dramatically from 41.4 mg/l to 1.43 mg/l.

Nitrate-Nitrogen, sulfate, fluoride, TDS and total hardness remained relatively unchanged. TSS improved from 650 mg/l to 31 mg/l.

Volatile organic compounds DCE, TCA, TCE and PCE were detected in low concentrations and remained relatively unchanged throughout the pumping period.

While temperature increased slightly, specific conductivity and pH generally remained unchanged.

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4.2.5 DW-28

Two groundwater samples were collected during the first and third day of the drawdown test in deep well DW-28. Total beryllium, cadmium and chromium concentrations were below the respective detection limits. Total copper levels were detected at 0.051 mg/l initially, then below the detection limit. Total iron concentrations decreased from 54.0 to 0.34 mg/l.

Fluoride, total hardness and TDS generally remained constant, and TSS decreased significantly from 1010 to <7 mg/l (detection limit).

Volatile organic compounds were generally found below detection limits or in low concentrations. DCA was detected initially at 2 μ g/l then below detection. Low levels of TCA were detected in concentrations of 4 and 3 μ g/l, respectively.

Temperature and specific conductivity decreased slightly, while pH increased slightly. Specific conductivity was moderately high and ranged from 1.626 to 1.709 mmhos/cm. Temperature values ranging from 16.7 to 17.8 are moderately high. Since the water level dropped to the pump intake, the pump motor probably heated the water slightly.

4.2.6 DW-29

Two groundwater samples were collected during the first and third day of the drawdown test in deep well DW-29. All total metals concentrations were above the respective detection limits, but decreased with increased pumping time. Total beryllium and cadmium decreased slightly, and chromium, copper and iron decreased significantly from 4.48, 5.96 and 22.2 to 0.59, 1.07 and 0.48 mg/l, respectively.

Fluoride decreased slightly from 21.6to 17.7 mg/l and total hardness and TDS increased slightly. TSS decreased from 290 to <7 mg/l.

Volatile organic compounds DCE and DCA were not detected above the detection limit. Methylene chloride was detected at 1 μ g/l in the second sample. This is most likely due to laboratory contamination. 1,2-DCE, TCA and PCE were detected in low levels and increased with pumping time by 1 μ g/l each.

Temperature and pH decreased slightly, while specific conductivity increased slightly. The temperature was moderately high. Although the water level during the drawdown test reached the pump intake, it is unlikely that the pump motor impacted the temperature significantly since the well sustained a pumping rate of 74 gpm. A final pH of 5.74 is moderately more acidic than typical groundwater pH values of 7 or greater for the area.

4.2.7 DW-32

Throughout the four days of pumping DW-32, a total of five groundwater samples were collected. Total beryllium, cadmium, chromium and copper concentrations remained relatively

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unchanged. Cadmium was generally detected in low concentrations just above the 0.010 mg/l detection limit. Total iron dropped from 19.1 to 0.37 mg/l during the testing period.

TDS, total hardness, fluoride, sulfate and nitrate-nitrogen concentrations were relatively unchanged or increased slightly. TSS improved from 330 mg/l to <5 mg/l (detection limit).

1,2-DCE, DCA, TCA, 1,1,2-TCA, TCE and PCE were detected in concentrations above the detection limits. DCE, DCA, TCA, and TCE concentrations are slightly elevated, while the other compounds were low or near detection limits.

Specific conductivity and pH were generally stable, while temperature increased slightly over time.

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5.0 HYDRAULIC CONTAINMENT

5.1 INTRODUCTION

The following section combines the results of the aquifer tests described previously along with data collected during the testing of monitor wells SW-9 and SW-19. Although a drawdown/recovery test was previously conducted on shallow well SW-15, the area of influence was minimal and the observed drawdowns in the observation wells were insignificant. Therefore, this well will not be considered as a viable groundwater extraction point. However, the drawdown/recovery tests that were completed on wells SW-9 and SW-19 produced more favorable results in terms of size of the area of influence and sufficient drawdown in observation wells. Further, these two wells are located near the center of the site and within the principal Solid Waste Management Units (SWMUs) area.

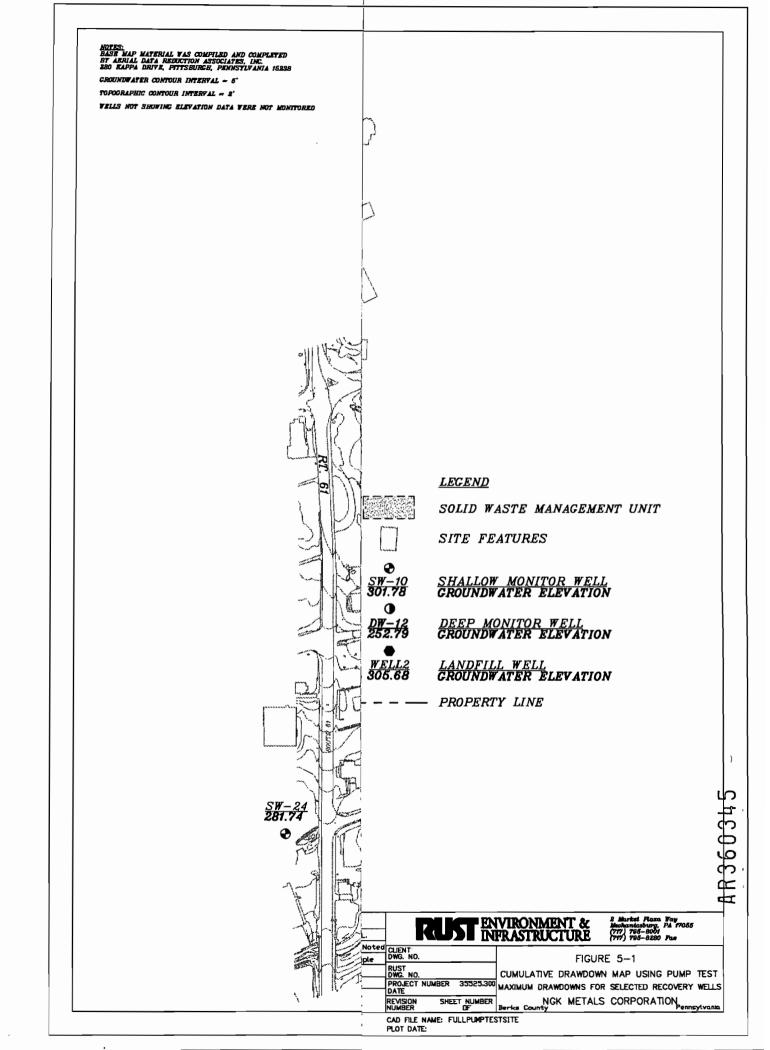
Specific details and quantitative analysis of the individual tests conducted on wells SW-9 and SW-19 are found in previous reports. Pertinent information from these tests is presented in the following discussion to assist in the development of an effective groundwater hydraulic containment system. Considering all available information, groundwater containment is achievable in two primary areas of concern. These two areas are near the northeast and southwest corners of the site, respectively. It is anticpated that a network of groundwater extraction wells located in these areas will effectively contain contaminated groundwater emanating from known sources, minimize contaminated groundwater from migrating off-site and provide a mechanism to transport contaminated groundwater to an appropriately designed water treatment facility located on site. Although the proposed hydraulic containment system focuses on the two respective areas, it is anticipated that positive impacts to groundwater quality will be realized site-wide.

In the following narrative both the northeast and southwest hydraulic containment systems are discussed. The recommended well configurations and pumping rates are based upon both static and drawdown water level data and known groundwater quality data. The selected groundwater extraction wells for both the northeast and southwest systems are primarily chosen so as to prevent the migration of chemical constituents from the site by controlling migration from known source areas. The system is not intended to capture impacted groundwater that has migrated off-site or to remote areas of the site. The hydraulic containment system is designed to capture affected chemical constituents in groundwater and prevent further migration to those areas.

Along with groundwater chemical data, drawdown data were the primary source of data used to select which wells should be used to achieve groundwater hydraulic containment. Although drawdown data were considered to be adequate quality, pumping would have had to continue for longer periods of time to allow the aquifer system to reach equilibrium. The drawdown data indicate that the areas of influence were still growing (expanding and deepening) before the tests were terminated. Therefore, it can be assumed that the estimated areas of capture presented in

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this report are minimum areas of capture that will become larger with time. Also, during the drawdown testing of wells DW-27 and DW-32, the groundwater levels at the site were at all time high levels since water level monitoring started in November of 1989 (see well hydrographs in Appendix F). Because the water levels were high and infiltration was occurring, areas of influence created by drawdown testing of wells DW-27 and DW-32 probably are not as large as they would have been during periods of more typical (i.e. lower) groundwater levels. Knowing this, recommended withdrawal rates have been carefully selected and take into account that some additional expansion will occur until equilibrium conditions are reached.

Additionally, drawdown data indicate that water levels in the shallow well system generally did not respond as much as the deep well counterparts when the deep wells were pumped. However, it is believed that when the aquifer system has been pumped for a sufficient duration (i.e., equilibrium), these shallow water levels will ultimately be fully impacted and mimic the water levels of the deeper wells within the area of influence. The shallow wells are more typically installed within the upper 100 feet of the surface and their open interval intersects more saturated soil profile than the deeper wells. As a result, it is expected that the shallow water levels will take a longer period of time to drain under the influence of gravity when compared to the more open fractured and solutioned bedrock that the deeper system typically intersects.

After the hydraulic containment system has been in operation and the aquifer system has achieved equilibrium, it is expected that naturally rising and falling groundwater levels (responding to periods of high and low infiltration) will continue to impact the areas of influence. When groundwater levels rise and fall the areas of influence will shrink and expand accordingly. As a result, a portion of the aquifer (the portion of the aquifer that is rewetted during a water level rise) will benefit from the resulting "flushing" action. Additional flushing will occur when a withdrawal well is taken off-line for unexpected or routine maintenance events.

5.2 GROUNDWATER COLLECTION SYSTEM - NORTHEAST

In the northeast portion of the site a former Retention Pond is a known source area for groundwater contamination. Chemical data indicate that groundwater in several wells in this area have been adversely impacted by this pond. Essentially, the pond is believed to be the primary source of chemical constituents in the groundwater. In addition to the Retention Pond, it is believed that former Pond 1 may be a contributing source to groundwater contamination in the northwestern wells. Therefore, groundwater hydraulic containment is necessary in this area. Sampling and analysis of groundwater collected from well DW-27 and DW-28 also indicated that groundwater contamination existed around well DW-27 but not DW-28. Because of these data, the area near well DW-27 was added to the area to be hydraulically contained. As a result, two wells (DW-27 and DW-29) were selected to create hydraulic containment in the area of the former Retention Pond.

Aside from shallow well SW-15, deep wells DW-27, DW-28 and DW-29 were pump tested in the northern one-half of the site. The radial area of influence (measured parallel to Tuckerton Road) from pumping well DW-28 was less than 200 feet and apparently was capable of directly

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impacting shallow well SW-21. Comparatively, the pumping data indicate that wells DW-29 and DW-27 each created a larger resultant area of influence. Both wells separately created an area of influence that appeared to extend in an east-west direction (parallels Tuckerton Road). Total diameter of influence (oriented along Tuckerton Road) for these wells combined is an estimated 600 to 700 feet. Well DW-28 is unnecessary as a withdrawal well because of the limited area of influence, anticipated low well yield (<5 gpm), and good water quality test results from groundwater samples collected during the drawdown test.

The area of influence created by pumping well DW-29 appears to have extended to just beyond shallow well SW-14 to the east and well DW-28 to the west. Pumping DW-29 created an area of influence more than sufficient to capture and contain groundwater beneath the entire former Retention Pond located in the northeast portion of the facility property. Pumping of well DW-29 is particularly important because the area of capture should prevent the migration of contaminated groundwater towards well SW-14 from both the former Retention Pond and former Pond 1. Historically, static water level contour maps have suggested that there is a groundwater hydraulic flow potential moving groundwater off-site to the northeast. Data from the drawdown test conducted on well DW-29 suggest that groundwater containment in the northeast corner of the site is achievable by pumping well DW-29 at a rate slightly less than the drawdown test rate of 74 gpm. Because the production rate of the well decreased (115 to 74 gpm) during the drawdown test, it is believed that the production rate will continue to drop until long term equilibrium is established within the aquifer. Therefore, an initial withdrawal rate of about 50 gpm is suggested for well DW-29.

The area of influence created by pumping well DW-27 appears to have extended just beyond well DW-28 to the east and nearly to well set 16 to the west. Pumping DW-27 created an area of influence larger than necessary for hydraulic containment in the area of well DW-27. Because groundwater at well DW-28 was clean, it is not necessary to create overlapping cones of depression. The area of influence created by drawdown testing well DW-27 extended beyond well DW-28 by an estimated 200 feet. To reduce the area of influence by about 200 feet so that it reaches just past well DW-28 will require a lesser pumping rate than was used for the drawdown testing. The new area of influence needs to be about 400 feet or approximately 57 to 66% of the estimated 600 to 700 foot total area of influence created by the drawdown test. Assuming that the drawdown test pumping rate needs to be adjusted similarly, then it is estimated that the well needs to be pumped at about 50 to 56 gpm.

Along the northeastern perimeter of the site, wells DW-27 and DW-29 will be sufficient to create drawdown zones (i.e. areas of capture) necessary to prevent off-site migration of groundwater. Pump test data suggest that the cumulative effect of pumping these wells may be overlapping areas of influence, although groundwater chemical data suggest that overlapping cones of depression will not be necessary in the area of DW-28. Shown on Figure 5-1 is a perspective of groundwater hydraulic containment system contour map that collates the area of influence data from well drawdown testing. Maximum drawdown data were combined and then subtracted from static groundwater levels collected on April 5, 1994. Figure 5-1 only shows cumulative drawdown data for the wells chosen to be used in the hydraulic containment system. The figure

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should only be used as a guide to better visualize the combined effects created by the drawdown testing.

After the hydraulic containment system has been in operation and the aquifer system has achieved equilibrium, it is expected that naturally rising and falling groundwater levels (responding to periods of high and low infiltration) will continue to impact the areas of influence. When groundwater levels rise and fall the areas of influence will shrink and expand accordingly. As a result, a portion of the aquifer (the portion of aquifer that is rewetted during a water level rise) will benefit from the resulting "flushing" action. Additional flushing will occur when a withdrawal wel is taken off-line for unexpected or routine maintenance events.

5.3 GROUNDWATER COLLECTION SYSTEM - SOUTHWEST

Chemical data indicate that groundwater in several wells in the southwestern portion of the site have been impacted by known (hydraulically) upgradient sources. These include Pond 2, Pond 3, and two red mud disposal areas located near the center of site. Groundwater from these source areas flows southwest. Historical water level data indicate this is the principal direction of groundwater flow in the southwestern area of the site. Groundwater hydraulic containment is necessary in this area to prevent off-site migration. As a result, a minimum of two wells are recommended (DW-12 and DW-32) to create hydraulic containment across the southwestern portion of the site. If necessary, well SW-8 could be added to enhance the hydraulic containment. As an alternative, data also suggest that hydraulic containment can be achieved along the southwestern perimeter of the site by pumping a combination of wells DW-12 and DW-32 in conjunction with injection to wells DW-8 and DW-13.

Aside from shallow wells SW-9 and SW-19, shallow well SW-8 and deep wells DW-12, DW-13 and DW-32 were pump tested in the southern one-half of the site. After drawdown data were reviewed wells SW-8, DW-12, and DW-32 were selected for further analysis as potential withdrawal wells. Wells SW-9 and SW-19 are not considered as groundwater extraction wells due to specifications of the proposed cap in this area.

Evaluation of water level data collected during the drawdown test at DW-13 indicates that the area of influence extended to Well 4 and well set 8 and as far as well DW-12 about 400 feet upgradient from well DW-13. As a result, the estimated total area of influence was about 800 feet, assuming the area of influence is symmetrical. However, due to the widespread number of wells in the extreme southwest corner of the site, the estimate of influence is only approximate. After careful evaluation of the other well drawdown test results, well DW-13 was eliminated as a possible extraction well because of location and the large rates of groundwater extraction that would create a smaller size area of capture than would pumping wells DW-32 and SW-8. However, well DW-13 is a prime candidate for receiving fairly large volumes of treated groundwater if used as an injection point.

The area of influence created by pumping well DW-12 appears to have extended to just beyond shallow well SW-8 and Well 4 to the northwest and well SW-12 to the east. Pumping DW-12

created an area of capture estimated to total about 500 to 600 feet (along the axis of pumping wells DW-12 and Well 4), assuming that the area of capture extends towards Laurel Run and is symmetrical. Drawdown data indicate that Well 4 was significantly impacted by pumping DW-12 and to a lesser degree well set 8. The resulting evaluation of maxximum drawdown water level elevations indicated that the water level drop seen in Well 4 was insufficient to reverse groundwater flow from the area of well set 8 and cause it to flow towards Well 4. Therefore, the area of capture was smaller than anticipated. However, drawdown data suggest that groundwater containment in the southwest corner of the site is achievable by pumping well DW-12 in conjunction with DW-32. To increase drawdown at Well 4, the rate of withdrawal for well DW-12 should be at a rate somewhat higher than the drawdown test rate of about 110 gpm. Therefore, an initial withdrawal rate of about 140 gpm is suggested for well DW-12. A withdrawal rate of 140 gpm represents an increase in pumping of about 27%.

The area of influence created by pumping well DW-32 appears to have extended just beyond well SW-7 to the northeast and nearly to Well 4 to the southeast. Pumping DW-32 created an area of influence estimated to total 400 feet, assuming the area of influence is symmetrical. Only well SW-7 was clearly impacted by pumping. However, data suggest that Well 4 and probably well DW-8 were impacted to a lesser extent. It is recommended that well DW-32 be pumped at the maximum production capacity of the well of about 9 gpm. In this way, the maximum area of capture may be realized from this well.

Drawdown data indicate that the estimated area of influence created by pumping well SW-8 to total 400 feet, assuming the area of influence is symmetrical. Wells DW-8, DW-13 and Well 3 were the only wells clearly impacted by pumping. Data also indicate that Well 4 was possibly impacted but only slightly. If necessary well SW-8 could be added to the hydraulic containment system to capture ground water escaping from between Well 4 and well DW-12. However, it is recommended that well SW-8 only be considered as a withdrawal well if deemed necessary. As stated above, an alternative to adding withdrawal wells would be to use well SW-8 and/or well DW-13 as injection points for treated ground water.

Actual pump test data collected from wells DW-12 and DW-32 suggest that overlapping cones of depression may develop after longer term pumping allows the ground water system to fully achieve equilibrium. Development and maturation of the overlapping cones of depression will likely be enhanced by the installation of the remedial RCRA caps over the various past disposal areas. The resulting overlapping cones of depression would approximately create a capture zone up to as much as approximately 1000 to 1200 feet in length if pumped simultaneously (through the axis of pumping wells DW-12 and 32). Therefore, it is believed that the total ground water withdrawal rate from the two wells would be about 150 gallons per minute. If after long term pumping the cones of depression do not overlap, then well SW-8 may need to be added to the hydraulic containment system. However, if it is determined that well SW-8 needs to be added to the system, total withdrawal from wells DW-12 and 32 would likely be reduced to offset the increase.

Shown on Figure 5-1 is a perspective of ground water hydraulic containment system contour map that collates the area of influence data from well drawdown testing. Maximum drawdown data were combined and then subtracted from static ground water levels collected on April 5, 1994. Figure 5-1 only shows cumulative drawdown data for the wells chosen to be used in the hydraulic containment system. The figure should only be used as a guide to better visualize the combined effects that were created by the drawdown testing.

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6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 General

- 1. Apparent ground water elevations and flow directions within the shallow (<100 feet) and deep (>100 feet) portions of the water table aquifer have remained consistent since previous investigations.
- 2. Drawdowns were measured in several observation wells for the respective pump tests conducted on wells SW-8, DW-12, DW-13, DW-27, DW-28, DW-29 and DW-32.
- 3. The seven pump tests, generally produced favorable results in terms of significant (i.e. <1 foot) drawdowns in several monitor wells greater than 150 feet away. This was the maximum radius of influence from three previous pump tests.
- 4. Generally, few wells located in the northern portion of the site exhibited reasonable yield (i.e. 5 gpm or more) to be considered for recovery wells. Four of the five new wells produce an estimated 5 gpm or better.
- 5. Overall pump test were of sufficient quality to determine approximate areas of influence and to provide adequate information to estimate pumping rates of selected wells to be used for groundwater extraction.
- 6. Based on available information, an initial estimate for cumulative pumping rate from four extraction wells (DW-12, 27, 29 and 32) is approximately 250 gpm.
- 7. Groundwater quality generally improved with time during pumping of wells SW-8, DW-12, DW-13, DW-28 and DW-29. Groundwater quality diminished slightly or remained relatively unchanged at wells DW-27 and DW-32.

6.1.2 Pumping Well SW-8

- 1. Well SW-8 was pump tested for approximately three days at an average rate of 28 gpm. Pumping rate varied from 30 gpm initially to 22 gpm near the end of the test.
- 2. The measured maximum drawdown in SW-8 was 14.04 feet, which was at the pump intake. The corrected drawdown, which accounts for the natural trend of the water table, was 13.69 feet.
- Well 3, DW-13, and DW-8 with 1.30 feet, 1.25 feet and 1.15 feet of (corrected) drawdown, respectively, were apparently impacted the most due to pumping of SW-8.

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4. The apparent effective radius of influence reaches well DW-13, which is approximately 250 feet away.

6.1.3 **Pumping Well DW-12**

- 1. Well DW-12 was pump tested for approximately four days at an average rate of 105 gpm. Pumping rate varied from 111 gpm, initially to 95 gpm near the end of the test.
- The measured drawdown in pumping well DW-12 was 42.86 feet. Corrected drawdown 2. was 42.11.
- 3. Monitored observation wells exhibiting more than one foot of drawdown (corrected for natural site-wide water table trends) include Well 1, Well 3, Well 4, SW-8, SW-12 and DW-13:
- 4. The radius of influence appears to extend to beyond well SW-8, which is more than 600 feet away.

6.1.4 **Pumping Well DW-13**

- 1. Well DW-13 was pump tested for approximately seven days at an average rate of 87 gpm. Pumping rate varied from 96 gpm, initially to 85 gpm near the end of the test.
- 2. The measured drawdown in pumping well DW-13 was 38.29 feet.
- 3. Monitored observation wells exhibiting more than one foot of drawdown (corrected for natural site-wide water table trends) include Well 1, Well 3, Well 4, SW-8, DW-12 and DW-8.
- 4. The apparent radius of influence extends to observation well DW-12, which is approximately 400 feet away.

6.1.5 **Pumping Well DW-27**

- 1. Well DW-27 was pump tested for four days at a rate of 90 gpm which gradually decreased to 85 gpm.
- The measured (uncorrected) drawdown in pumping well DW-27 was 32.84 feet. 2.
- 3. Water levels in wells DW-28, SW-23 and DW-15 were impacted the most due to pumping. Respective drawdowns were 7.36 feet, 3.06 feet and 2.03 feet.
- 4. The apparent area of influence extends towards the east to at least well SW-23, and towards the southeast to at least well DW-15. These wells are approximately 325 and 300 feet from the pumping well, respectively.

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6.1.6 Pumping Well DW-28

- 1. Well DW-28 was pump tested for approximately three days at an average rate of 8 gpm. Pumping rate varied from 15 gpm, initially to 4 gpm near the end of the test.
- 2. The measured (uncorrected) drawdown in pumping well DW-28 was 40.40 feet.
- 3. SW-21 and SW-23 with 7.06 feet and 0.91 feet of (corrected) drawdown, respectively, were apparently impacted the most due to pumping of DW-28.
- 4. The apparent radius of influence extends to observation well SW-21, which is approximately 230 feet away. Well SW-21 appears to be uniquely connected to the pumping well, since observed drawdowns in wells located between the two were insignificant relative to the drawdown in SW-21.

6.1.7 Pumping Well DW-29

- 1. Well DW-29 was pump tested for approximately three days at an average rate of 87 gpm. Pumping rate varied from 115 gpm, initially to 74 gpm near the end of the test.
- 2. The measured drawdown in pumping well DW-29 was 41.39 feet. Corrected drawdown in the pumping well was 41.28 feet.
- 3. Monitored observation wells exhibiting more than one foot of drawdown (corrected for natural site-wide water table trends) include SW-14, SW-23, DW-15, DW-28 and DW-30.
- 4. The apparent radius of influence extends to observation well DW-28, which is approximately 300 feet away.

6.1.8 Pumping Well DW-32

- 1. Well DW-32 was pump tested for approximately four days at a rate of approximately 9 gpm.
- 2. The measured (uncorrected) drawdown in pumping well DW-32 was 63.19 feet.
- 3. Well SW-7, located approximately 200 feet away, was the only well that showed drawdown of at least one foot. The drawdown was 2.28 feet.
- 4. Pumping well DW-32 created an area of influence that extended to beyond well SW-7 towards the northeast and nearly to Well 4 towards the southeast. Well 4 is located approximately 260 feet from DW-32.



APPENDIX A

WELL LOGS

	Geoscie		•		Te	est Bo	oring	g/Well Con	struction	ı Log
Project: RFI						Boring No. MW	Boring No. MW-5A			
Client :	N	GK Me	tals Co	rporation					Sheet 1 of 2	
Purpos	e: M	Ionitori	ng Wel	l Installati	on				Job No. 37-3943	3-5756
Drilling	g Contra	ctor : E	ichelbe	rger		Dı	iller :	C. Knaub	Total Depth 48	ft.
Geolog	ist: J.	J. Pain	ter		Specifica	ations Type	Diameter	Hammer Weight: 1bs.	Date Started 8/28	3/89
Time Log	g: Beg	in	Finish	Depth	Casing	steel	6 in.	Notes: 4 in. pvc .02 slot screen from 48'-	Date Finished9/1	5/89
					Bore	rock/ unconsol.	10 in.	28', #1 morie sand	S.W.L. 25.55 ft.	TOC/GL
					Well	pvc	4 in.	48'-36', 1B quartzite 36'-23', ben-	Elevation TOC	
					Sampler		_	tonite 23'-22.5', grout 22.5'-0'	329.56 ft.	327.42 ft
Depth (Feet)	Sample Numbers	Blow Counts		ual Log cription		Litholo	gic De	scription	Note	S
20					0-9' 9-40'	qu do lig an	artzite lomite ht brov d grave	mud), sand, gravel (fill), fragments. wn clay, sand, el	damp	ed water
50 —				collapsed collapsed to the second sec	41-60'	int da an lin	rk grey d doloi	ent weathered, y, pyritic shale mite grades to e with mud	~2 gpm	

Dunn Geoscience	e Corporation	Test Boring/Well Con	struction
Mechanicsburg, PA	struction		
Project: RFI	Boring No.MW-5A		
Client: NGK	Metals Corporation		Sheet 2 of 2
	low Visual Log ounts Description	Lithologic Description	Notes
60		60-61' weathered dolomite mud/water filled void 69-71' medium to dark grey dolomite void medium to dark grey dolomite intermittent medium to dark grey dolomite/voids 73-93' competent bedrock medium grey dolomite	note: while reaming the bore hole, cuttings returned: dolomite, quartzite pebbles snd gravel, quartz fragments, shale, leached dolomite the 6 in. steel casing was pulled back and the hole stayed open to 45' and well was constructed final estimated flow is >10 gpm

Dunn Geoscience Corporate Mechanicsburg, PA (717) 671-67		Te	est B	oring	g/Well Con	struction	n Log
Project: RFI						Boring No. MW	-5B
Client: NGK Metals C	orporation		_			Sheet 1 of 3	
Purpose : Monitoring We		on			_	Job No. 3943-5-	-5756
Drilling Contractor: Eichelb	erger		r	Oriller : I	Funk/Knaub	Total Depth 175	5 ft.
Geologist: J. J. Painter/S. B.	Suter	pecifica	tions Type	Di ameter	Hammer Weight lbs.	Date Started 10/	3/89
Time Log: Begin Finish	Depth (Casing	steel	6"x100'	Notes: quartzite grav- el fill 37'-10', grout	Date Finished 10	0/31/89
		and	steel	7'x10"	the remaining inter-	S.W.L. 26.58 ft	
		Well	open	6"	val to 97', used drill- ing foam to 97' to	Elevation TOC	
	1	Bore	rock	6"	help lift cuttings	329.62 ft. L	B27.62 ft.
	sual Log scription		Lithol	ogic Des	scription	Note	s
10		20-23' 23-25' 25-35.:	5'	shale and medium limeston fractured	to dark grey e	severel weather medium grey water in fracture (no esti	red n-dark n the ed zone

Dulin Geoscient	ce Corporation	Test Boring/Well Con	4.
Mechanicsburg, PA	struction		
Project: RF	Boring No. MW-5B		
Client: NG	K Metals Corporation		Sheet 2 of 3
	Blow Visual Log Counts Description	Lithologic Description	Notes
	Counts Description	limestone, as above with light brown clay, chert weathered limestone, limonite, severely leached medium to dark grey limestone limestone, as above with light brown clay clay/ water filled void clay/ water filled void	

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Dunn Geoscie Mechanicsburg,			Test Boring/Well C	onstruction
Project: R	FI			Boring No. MW-5B
Client: N	GK Met	tals Corporation		Sheet 3 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
140			140-175' medium to dark grey limestone	final estimated flow is <2 gpm

Dunn Geoscien	ce Corporati	on	Te	est Borins	y/Well Con	struction Log
Mechanicsburg, P.	A (717) 671-67	10				
Project: R	FI	_				Boring No. MW-6A
Client: No	GK Metals Co	rporation				Sheet 1 of 1
Purpose: M	onitoring Wel	l Installatio	on			Job No. 37-3943-5756
Drilling Contrac	ctor: Eichelbe	erger		Driller :	K. Weigle	Total Depth 51 ft.
Geologist: J.	J. Painter		Specifica	ations Type Diameter	Hammer Weight lbs.	Date Started 8/30/89
Time Log: Begin	n Finish	Depth	Casing	steel 6"x22'	Notes: 4 in. pvc .02	Date Finished 8/30/89
			Bore	rock/ uncons. 6"	slot screen with poly- ester wrap from 51'-	S.W.L. 33.91 ft. <u>TOC/GL</u>
			Well	pvc 4"	31', #1 morie sand and formation gravel	Elevation TOC Surface
			Sampler		51'-22.5', bentonite 22.5'-21.5', grout to 0'	327.99 ft. 326.04 ft
- I - I	Vis	ual Log			-	
Depth Sample (Feet) Numbers	Blow Counts Des	scription		Lithologic De	scription	Notes
20			0-1' 1-5' 5-7' 7-11' 11-12' 12-17' 17-22' 22-25' 25-27' 27-41'	brown to brown cl dark brown cl dark brown cl to brown sand, qua as above gravel reddish the clay, as a coarse greddish the sandy clay, as a coarse gredish the sandy clay as a coarse gredish the coarse gredish the sandy clay as a coarse gredish the sandy clay as a coarse gredish the sandy clay a	ay and silt wn silt (fill) to brown clay artzite gravel with very coarse brown clay, sand, gravel above with ravel brown clay, above with ravel bove, coarse sand	wet @ 8' used water and foam to return cuttings
50			42-51' 51'	dolomite medium dolomite (iron sta		

DUNN GEOSCIENCE CORPORATION

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	Geoscier csburg, P		_		T	est B	oring	g/Well Con	struction	1 Log
Project		FI	,0,1-0,						Boring No. MW	-7A
Client:	<u> </u>		tals Co	rporation					Sheet 1 of 2	
Purpose				ll Installat	_				Job No. 37-3943	3-5756
	Contra					D	riller :]	K. Weigle	Total Depth 75	_
Geolog		J. Pain			Specific		Diameter	Hammer Weight lbs.	Date Started 9/1	1/89
Time Log		n	Finish	Depth	Casing	steel	6"x 21'	Notes: 4" pvc .02 slot	Date Finished 9/	11/89
					Bore	rock/ uncons	6"	screen with polyester wrap 68'-48', #1 mor-	S.W.L. 41.18 ft.	TOC/GL
					Well	pvc	4"	ie sand and formation gravel 68'-33', ben-	Elevation TOC	Surface
					Sampler			tonite 33'-32', grout 32'-0'	320.71 ft.	318.95 ft
Depth (Feet)	Sample Numbers	Blow Counts	De	sual Log scription		Litholo	ogic De	scription	Note	s
10					0-5' 5-8' 8-60'	re gr li si	ddish baravel, an	nd soil fill brown clay, and sand wn to brown , gravel, and	damp	
20									31' used and foa return c	m to help
40										

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Dunn Geoscience Co	struction		
Project : RFI	Boring No MW-7A		
Client : NGK Metals	Corporation		Sheet 2 of 2
Depth Sample Blow (Feet) Numbers Count		Lithologic Description	Notes
60		60-63' clay and gravel as above 63-64' weathered limestone, iron stained 64-70' medium gray limestone, oolitic 70-75' medium to dark grey limestone, trace brown sandy layer	final flow is ~2 gpm

Dunn Geoscience Mechanicsburg, PA (-		Te	est Bo	oring	g/Well Con	struction	n Log
Project: RFI							Boring No. MW-	-8A
	Metals Co	rporation					Sheet 1 of 2	
	toring Wel		n				Job No. 37-3943	3-5756
Drilling Contractor				D	riller : H	ζ. Weigle	Total Depth 61	ft.
	ainter		Specifica		Diameter	Hammer Weight lbs.	Date Started8/29	/89
Time Log: Begin	Finish	Depth	Casing	steel	6" x 21'	Notes:4" pvc .02 slot	Date Finished 9/	29/89
			Bore	rock/	6"	screen 57'-37', #1 morie sand 57'-34.5',	S.W.L. 36.08 ft.	TOC/GL
			Well	uncons pvc	4"	bentonite 34.5'-34', grout 34'-0'	Elevation TOC	Surface
		S	Sampler			5.00. 5. 0	304.71 ft.	303.23 ft.
	AW	ual Log cription		Litholo	gic Des	scription	Note	s
20			0-2' 2-9' 9-11' 11-14' 14-17' 17-38'	br br sn re cl cl la ve br	ith brich rown to rown clanall quaddish bay ay, as a rge qua	reddish ay, sand and artzite gravel rown sandy bove, with rtzite gravel se gravel, mestone	moist to 21' used to help cuttings water @ approx	l water return
40			38-41' 41-48' 48-53' 53-60'	lir m lir ap vo le m do lig lir	nestone edium to mestone opears in ached continue to mestone opears in ached continue to mestone opears in ached continue	to dark gray e, broken to dark gray e, dolomite this interval thered zone arbonate to dark gray with thin thedium gray e laminae, ed to fresh.	44-46' large cu	

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1			poration	T	est Boring/Well C	onstr	uction
		PA (717) .FI	671-6710				
Project Client			tals Corporation			_	ng No. MW-8A
						Snee	. 1 2 01 2
Depth (Feet)	Sample Numbers		Visual Log Description		Lithologic Description		Notes
60_				60-61'	light to medium grey limestone laminae, weathered to fresh		final flow is ~30 gpm
70							
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	ience Corpora , PA (717) 671-6		Te	est B	oring	g/Well Con	struction	1 Log
Project :	RFI						Boring No. MW	-8B
Client:	NGK Metals (Corporation					Sheet 1 of 3	
Purpose:	Monitoring W	ell Installatio	on				Job No. 3943-5-	5756
Drilling Cont	ractor: Eichel	berger		D	riller:		Total Depth 151	ft.
Geologist :	J. J. Painter		Specifica	ations Type	Diameter	Hammer Weight lbs.	Date Started 10/2	24/89
Time Log: B	legin Finish	Depth	Casing	steel	6"x110'	Notes: used foam to	Date Finished 10	/25/89
			and	steel	10"x56'	40' to help lift cut- tings	S.W.L. 36.48 ft.	TOC/GI
			Well	open	6"		Elevation TOC	Surface
		1.	Bore	rock	6"		304.58 ft.	303.43 fi
Depth Sampl (Feet) Number	e Riow L	isual Log	0-32'			scription	Note	s
10			32-40' 40-50'	С	arbonat	weathered e rock arbonate rock,		
50			50-56'	n li	ned to d	e water ark grey e, quartz healed, eins		ractured ater < 50
60			56-60'	li		ark grey e, competent, einlets		

Dunn Geoscience Corporation Test Boring/Well Construction Mechanicsburg, PA (717) 671-6710 RFI Project: Boring No. MW-8B NGK Metals Corporation Client: Sheet 2 of 3 Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 60 60-126' medium to dark grey limestone, more competent, calcite veinlets 70. 80_ 100 110_ 120 medium to dark grey dolomite, softer, trace iron staining 126-140' 130

140

		FI (717)	671-6710			Boring/Well Co	
Project	•		1- Oi-				Boring No. MW-8B
Client :			tals Corpoatio	1			Sheet 3 of 3
	Sample Numbers	Blow Counts	Visual Log Description		Lit	hologic Description	Notes
140				7	10-141' 11-151'	med to dark grey dolomite, softer medium to dark grey limestone	trace iron staining
50 _							final flow is ~4 gpm
60		_					
=							
			-				
\exists							

Dunn G			-		Te	est B	oring	/Well Con	struction	Log
Project	: R	FI							Boring No. MW-9)A
Client:	N	GK M	etals Co	rporation					Sheet 1 of 2	_
Purpose	: M	lonitor	ing Wel	l Installati	on				Job No. 37-3943-	5756
Drilling	Contra	ctor: 1	Eichelbe	rger		D	riller : F	(Weigle	Total Depth 75 ft	
Geologi	ist: J.	J. Pair	nter		Specifica	itions Type	Di ame ter	Hammer Weight: lbs.	Date Started 9/7/8	19
Time Logs	: Begi	in	Finish	Depth	Casing	steel	6" x 62'	Notes:	Date Finished 9/7	/89
					Bore	rock	6"		S.W.L. 27.28 ft.	TOC/GL
					Well	open	6"		Elevation TOC	Surface
					Sampler				333.22 ft.	
		D1	Vis	ual Log			. ~			
Depth (Feet)	Sample Numbers	Blow Counts	Des	cription		Litholo	ogic Des	scription	Notes	
10					0-1' 1-9' 9-35' 35-37' 37-55'	co sn at m w cl	d mud parse grandl bou 10', tra aterial, ard with ay conte	avel and liders, wood ace cinder fining down- increasing ent avel and avel, clay and	7.35 ft. of 6" ste added 3/93 wet @ 9 used wa foam @	ter and
40 <u> </u>					55-60'	sr m	nall bou	alders		

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	Geoscie				Te	est Boring/Well Cor	struction
Projec	t: R	FI			<u> </u>		Boring No. MW-9A
Client	: N	GK Met	als Corp	oration			Sheet 2 of 2
Depth (Feet)	Sample Numbers	Blow Counts	Visual Descri		Lithologic Description		Notes
70					60-69' 69-75'	medium to dark gray limestone weathered limestone, broken,trace sandstone cuttings	final flow is ~20 gpm
80 _		_					
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Dunn Geoscience Corporation Mechanicsburg, PA (717) 671-6710		Test	t Bor	ing	g/Well Con	struction Log
Project: RFI						Boring No. MW-9B
Client: NGK Metals Corpo	ation					Sheet 1 of 3
Purpose: Monitoring Well Ins		1				Job No. 3943-5-5756
Drilling Contractor: Eichelberge			Drill	er : K	Cnaub/Weigle	Total Depth 200 ft.
Geologist: S. B. Suter		pecification	is Type Di	ame ter	Hammer Weight lbs.	Date Started 10/27/89
Time Log: Begin Finish De	pth Ca	asing sto	eel 6'	x125	Notes: quartzite grav- el fill 86'-10', grout	Date Finished 10/30/89
		and ste	eel 10		the remaining inter-	S.W.L. 33.78 ft. <u>TOC/GL</u>
	V	Well of	pen 6	5"	val to 125'	Elevation TOC Surface
	B	Bore ro	ock (5"		333.63 ft.
Depth Sample Blow Counts Description		Li	thologic	Des	scription	Notes
10	52	2-55' 5-60'	wea bou med lime	there lder ium	ed limestone to dark grey e, calcite,	8.03 feet of 6" casing adde 3/93

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	Geoscie				Test	Boring/Well Co	nstruction
Projec	t: R	FI					Boring No. MW-9B
Client	: N	GK Mei	als Corp	oration			Sheet 2 of 3
Depth (Feet)	Sample Numbers	Blow Counts	Visual Descri		Lith	ologic Description	Notes
60					84-86' 86-118'	medium to dark grey limestone, calcite, fractured clay filled void severely fractured limestone	
120					118-124.5' 124.5-125' 125-140'	medium to dark grey limestone fractured zone medium to dark grey limestone	

Dunn Geoscience Co		Test Boring/Well	Construction		
Mechanicsburg, PA (717) 671-6710 ———————				
Project: RFI	Boring No. MW-9B Sheet 3 of 3				
Client: NGK Me	Client: NGK Metals Corporation				
Depth Sample Blow (Feet) Numbers Counts	Visual Log Description	Lithologic Description	Notes		
150		medium to dark grelimestone	final estimated flow is <2 gpm		

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Dunn Geoscience Co Mechanicsburg, PA (71)			Te	est Bo	oring	g/Well Con	struction	Log
Project: RFI		!		_			Boring No. MW-	10A
	etals Corporation	n					Sheet 1 of 1	
	ring Well Installa	ation		_			Job No. 37-3943	-5756
Drilling Contractor :	Eichelberger			D	riller : I	K. Weigle	Total Depth 51 f	t.
Geologist: J. J. Pair		Spe	ecifica	tions Type	Di ame ter	Hammer Weight lbs.	Date Started 10/1	1/89
Time Log: Begin	Finish Depth	Ca	sing	steel	6" x 23'	Notes: 4" pvc .02 slot	Date Finished 10	/12/89
		E	Bore	rock/ uncons	10"	screen with polyester wrap 41'-21', #1 mor-		TOC/GL
		W	/ell	pvc	4"	ie sand and formation gravel 41'-21', ben-	Elevation TOC	
		San	npler			tonite 21'-20', grout 20'-0'	312.80 ft.	311.50 ft
Depth Sample Blow (Feet) Numbers Counts	l Description			Litholo	gic De	scription	Notes	<u> </u>
20			-21' '-41'	ver bou	alders,	e gravel, small and sand sand, and gravel	damp @) 8 '
50		41		dar lec	rk gray ige	limestone	10" cab hanging final flo ~3 gpm	le tool bir up w is

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Dunn Geoscies Mechanicsburg, F	nce Corporati PA (717) 671-67		Te	est B	oring	g/Well Con	struction Log
Project: R	FI						Boring No. MW-10B
Client: N	GK Metals Co	rporation					Sheet 1 of 2
Purpose: N	Ionitoring Wel	l Installatio	on				Job No. 37-3943-5756
Drilling Contra	ctor : Eichelbe	erger		D	riller : l	Funk/Knaub	Total Depth 123 ft.
Geologist: J.	J. Painter	. [Specifica	tions Type	Di ame ter	Hammer Weight lbs.	Date Started 10/11/89
Time Log: Beg	in Finish	Depth	Casing	steel	6" x 94'	Notes: 10" steel cas-	Date Finished 11/1/89
			and	steel	10" x35'	ing installed to 35' with cable tool, 10"	S.W.L. 18.47 ft. <u>TOC/</u> GL
			Well	open	6"	hammer bit to 92', 6" hammer bit to 123	Elevation TOC Surface
			Bore	rock	6"	quartzite gravel fill 50'-17'	313.15 ft. 311.90 f
Depth Sample (Feet) Numbers			0-0.5'	d	ark bro	scription wn topsoil	Notes
10		* *:1:	0.5-2' 2-6' 6-21'	be Ve	oulder ery coa	rown clay rse gravel, all boulders	
20			21-35'		ed clay, ravel	sand, and	
- - - 40_			35-41'	se	rown to everly v meston	olive grey veathered e	
50_			41-60'	li: 0:	mestone f chert f	to dark grey e, trace amounts fragments, al weathered gments	

Mechanicsburg Project:	RFI	, , , , , , , , , , , , , , , , , , , ,			Boring No. MW-10B	
Client:		tals Corporation			Sheet 2 of 2	
Depth Samp (Feet) Numb	le Blow	Visual Log Description	Lith	nologic Description	Notes	
70— 			60-104' 104-106' 104-115'	medium to dark grey limestone, trace amount of chert fragments, occasional weathered shale fragments mud/water filled crack, rock not very broken medium to dark grey limestone, more competent rock mud/water filled void with broken limestone	final flow is ~10 gpm	

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Dunn Geoscieno Mechanicsburg, PA	-		Te	est B	oring	g/Well Con	struction	n Log
Project: RFI								-11 A
Client: NGK Metals Corporation								
Purpose: Monitoring Well Installation								5756
Drilling Contracto	or: Eichelb	erger		D:	riller : I	Funk/Knaub	Total Depth 73	ft.
Geologist: J. J.	Painter		Specifica	itions Type	Di ame ter	Hammer Weight: lbs.	Date Started 10/	30/89
Time Log: Begin	Finish	Depth	Casing	steel	8"x11'	Notes:	Date Finished 10)/31/89
			and	steel	6"x20'	1	S.W.L. 29.35 ft.	TOC/G
			Well	open	6"	1	Elevation TOC	Surface
			Bore	rock	6"	1	330.0 ft.	328.0 ft
	Vis	ual Log						_
		scription		Litholo	gic De	scription	Note	S
10			0-11' 11-33' 33-34' 34-60'	me lim	clay, sil	n, fill, consisting t, sand, wood and dark grey trace dolomite		

Dunn Geosci Mechanicsburg,			Test Boring/Well Construction			
Project: R	FI				Boring No. MW-11A	
Client: N	GK Me	tals Corporati			Sheet 2 of 2	
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	L	ithologic Description	Notes	
60			60-73'	medium to dark grey limestone	final flow is ~2 gpm	

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Dunn Geoscience Corporation				Test Boring/Well Construction Log				
Mechanicsburg, PA								
Project: RFI								-12A
Client: NGK Metals Corporation								
r	onitoring Wel		on				Job No. 37-3943	3-5756
Drilling Contract					riller : l	E. Funk	Total Depth 60	ft.
Geologist: J. J.	. Painter		Specifica	tions Type	Di ame ter	Hammer Weight lbs.	Date Started 9/29	9/89
Time Log: Begin	Finish	Depth	Casing	steel	6"x12'	Notes: 4" pvc .02 slot screen with poly-	Date Finished 10)/4/89
			Bore	uncons	10"	ester wrap 55'-35',	S.W.L. 22.32 ft.	TOC/GL
			Well	pvc	4"	#1 morie sand and formation gravel	Elevation TOC	1
			Sampler			55-47', grout 12'-0'	311.60 ft.	309.40 ft
Depth Sample (Feet) Numbers		sual Log scription		Litholo	gic De	scription	Note	s
20			,	coarse	sand, a	and and quartzite	moist @	9'
50 _			51'-52'	el, trac materi weathe grey li and cla brown quartz	ce small al as ab ered sha meston ay		final flo ~5 gpm	

Dunn Geoscie Mechanicsburg, I			Test	Boring/Well Co	nstruction
	FI			·	Boring No. MW-12B
Client: N	Sheet 3 of 3				
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Liti	hologic Description	Notes
140			140-155'	clay filled void, silty, light brown	final flow is ~100 gpm

			poration 671-6710	Test	Test Boring/Well Construction			
Project :	: R	FI		· · · · · · · · · · · · · · · · · · ·		Boring No. MW-13B		
Client:	N	GK Met	als Corporation			Sheet 2 of 3		
(Feet) N	Sample Numbers	Blow Counts	Visual Log Description	Lit	hologic Description	Notes		
60				60-105'	medium to dark grey limestone, interbedded with dolomite, calcite veinlets, some quartz healed cracks			
110				105-123'	medium to dark grey dolomite with quartz veinlets			
130				123-127' 127-162'	medium gray lime- stone medium to dark gray dol- omite			

Dunn Geo Mechanicsbu		-		Γ	est B	oring	g/Well Con	structio	n Log
Project :	RFI							Boring No. MW	/-13B
Client:	NGK	Metals	Corporation	n				Sheet 1 of 3	
Purpose :	Mon	itoring \	Well Installa	ation				Job No. 37-394	3-5756
Drilling Co	ontracto	r : Eich	elberger	_	D	riller : l	E.Funk/C.Knaub	Total Depth 10	5 ft.
Geologist :		Painter		Specifi	cations Type	Diameter	Hammer Weight lbs.	Date Started 10	/5/89
Time Log:	Begin	Finis	h Depth	Casing		105x6"	Notes:	Date Finished 1	0/24/89
Τ	_	T		and	steel	42x10"	1	S.W.L. 35.24 f	t. <u>TOC</u> /GI
		-		Well	open	6"	1	Elevation TO	Surface
-		 		Bore	rock	6"	-	304.45 ft.	301.83 f
<u></u>		,	Visual Log	+					_
	4	low ounts	Description		Lithol	ogic De	scription	Note	es
10				5-18'	gr O' g	ravel,sa	earse sand,		
40 <u> </u>				## 41-4	9' n	eathere	dark grey		
50				49-5: 53-5:	9-53' intermittent zones of dolomite, brown to olive brown shale			clay fil	gravel and led s w/water
60				55-60 E	0' n		dark grey		

Dunn Geoscience Mechanicsburg, PA	-		Te	est B	oring	g/Well Con	struction	ı Log
Project: RFI	[I				Boring No. MW	-12B
	Metals Co	rporation					Sheet 1 of 3	
Purpose: Mon	itoring Wel	l Installation	1 .				Job No. 37-394	3-5756
Drilling Contracto	r: Eichelbe	erger		D	riller : I	E. Funk/ Knaub	Total Depth 160	ft.
Geologist: J. J. P	ainter/S. B.	Suter S _r	ecifica	tions Type	Diameter	Hammer Weight lbs.	Date Started 10/	4/89
Time Log: Begin	Finish	Depth C	asing	steel	100' x 6"	Notes:	Date Finished 10)/27/89
			amd	steel	27'x 10"		S.W.L. 24.86 ft	. TOC/GL
		7	Vell	open	6"		Elevation TOC	
		F	Bore	rock	6"		307.83 ft.	305.90 ft.
* · · · · ·		sual Log scription			<u> </u>	scription	Note	s
10		5.5 8.8 1.1 2.1 2.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3 3.3	-5' -8' -15' 5-21' 4-30' 0-33' 3-35' 5-60'	sn co gr lig we tra mi lir fra mi	arse gra avel,sar avel,sar ce calc edium t nestone actured ud filled	avel,sd,clay ark grey d dolomite, ite o dark grey zone, water d void o dark grey	21-22' 1 ledge o	rock or boulder

Dunn Geoscie	ence Co	rporation	Т	oat 1	Paning/Wall Con	estmuotion
Mechanicsburg, l	PA (717)	671-6710	1	est l	Boring/Well Con	Struction
Project: R	FI			Boring No. MW-12B		
Client: N	IGK Me	tals Corporation				Sheet 2 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description		Litho	ologic Description	Notes
60			84-86 86-10	; '	fractured zone medium to dark grey limestone and dolomite	

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Ounn Geoscience Corporation Mechanicsburg, PA (717) 671-6710 Test Boring/Well Construction				
	FI			Boring No. MW-13B
	IGK Met	tals Corporation		Sheet 3 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
140			153-158' fractured zone, mud and water	final flow is ~20 gpm

Mechanicsburg, P	nce Corporati A (717) 671-67		Te	est Bo	oring	g/Well Con	struction	n Log
Project: R	FI						Boring No. MW	-14A
Client: N	GK Metals Co	rporation					Sheet 1 of 2	
Purpose: M	Ionitoring Wel	l Installatio	n				Job No. 3943-5	 -5756
Drilling Contra	ctor: Eichelb	erger		D	riller :	K. Weigle	Total Depth 76	ft.
Geologist: J.	J. Painter	S	Specifica	itions Type	Diameter	Hammer Weight lbs.	Date Started 9/1	9/89
Time Log: Begi	in Finish	Depth (Casing	steel	11'x 6"	Notes: 4" pvc .02 slot	Date Finished 9/	/19/89
			Bore	rock/ uncons	10"	screen 68'-48' with polyester wrap, #1	S.W.L. 50.96 ft.	TOC/GI
			Well	pvc	4"	morie sand 70'-44', bentonite 44'-42',	Elevation TOC	Surface
		s	ampler			grout 42'-0'.	² 327.97 ft.	326.54 f
Depth Sample		ual Log		T 1.1 1	· D			
Depth Sample (Feet) Numbers	.Counts Des	scription		Litholo	gic De	scription	Note	S
10)-1' -10' (0-36'	b ci sl li au	ght bro	wn topsoil o orange brown id, trace brown gments wn silt, gravel il boulders wn to orange ay with light reathered shale	quartzi	te gravel

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			671-6710			Boring/Well Cor	T
Project: RFI							Boring No. MW-14A
Client	: NO	JK Met	als Corporation				Sheet 2 of 2
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description		Lith	nologic Description	Notes
60 70			pase	60-´		light brown to orange brown clay with light brown weathered shale light brown shale with olive grey to light grey	moist
			collapsed			olive grey to light grey dolomite	final estimated flow is <5 gpm
80							
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Dunn Geo	oscience (Corporati	on	T	net R	orino	g/Well Con	struction	1 0g
Mechanicsb	urg, PA (7	717) 671-67	10	1,	est D	אַנונו נוט	g/ vv en Con	su ucuoi	Log
Project:	RFI						-	Boring No. MW	-15A
Client:	NGK I	Metals Co	rporation					Sheet 1 of 2	
Purpose:	Monit	oring Wel	l Installati	ion				Job No. 37-394	3-5756
Drilling C	Contractor	: Eichelbe	rger			riller : (C. Knaub	Total Depth 68 f	t.
Geologist	; J. J. Pa	ainter		Specifica	itions Type	Diameter	Flammer Weight ibs.	Date Started 9/2	
Time Log:	Begin	Finish	Depth	Casing	steel	11'x 6"	Notes: 4" pvc .02 slot screen 66.5'-46.5', #1	Date Finished 9/	21/89
				Bore	rock	10"	morie sand 66.5'-43', bentonite 43'-42',	S.W.L. 39.83 ft.	
				Well	pvc	4 "	grout 42'-0	Elevation TOC	
				Sampler				329.56 ft.	327.62 ft.
	ample Blo imbers Cour	W Des	ual Log cription		Litholo	ogic De	scription	Note	S
20				0-3' 3-9' 9-14' 14-26' 26-28' 28-33' 33-35' 35-55'	br lin do as of do br sh do on	nestone plomite, above, live gre- plomite roken/wale/san plomite range br	edium grey e,olive grey e,olive grey weathered with clay y shale and veathered dy shale & rown clay to dark grey	used fo to help cuttings	
50				55-57'	VC	oid, brov	wn clay filled	fracture	e @ 48'
60				57-60'	da	rk grey	limestone		

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Dunn Geosci Mechanicsburg,			Test Boring/Well Co	onstruction
Project: F	FI			Boring No. MW-15A
	IGK Met	als Corporation		Sheet 2 of 2
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
60		collapse	dark grey limestone	final flow is ~10 gpm

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Dunn Geoscience (-		Te	est B	oring	g/Well Con	struction I	Log
Project: RFI		,					Boring No. MW-15B	<u> </u>
	Metals Corp	poration					Sheet 1 of 3	
	oring Well	`	n				Job No. 37-3943-57	56
Drilling Contractor					riller : F	Cnaub	Total Depth 175 ft.	
Geologist: J. J. P.		_	Specifica		Diameter	Hammer	Date Started 9/22/89	
Time Log: Begin	Finish	Depth (Casing	steel	118'x 6"	100.	Date Finished 9/22/8	9
		- +	Bore	rock	6"			OC/GL
			Well	open	6"		-	Surface
		Si	ampler	- Open			329.63 ft. 323	7.66 ft
	Visua	al Log						
Depth Sample Blo (Feet) Numbers Cou	Descr	ription		Litholo	gic Des	scription	Notes	
10			0-5' 5-10' 10-14' 14-35'	med.coccas sands broke weath shale	dark gresional retone francered of and dolors sional thered is ments not a grey dispersed to the control of the	nedium mestone, olive grey	3-5':brown cl 5-6':weathere olive gre dolomite 6-7': calcite laminae 7-9':brecciate pink dole 9-10':yellowi brown dolomite	ed y ee ed omite sh

Dunn Geoscier Mechanicsburg, PA	nce Corporation A (717) 671-6710	Test Boring/Well Con	struction
Project: R F			Boring No. MW-15B
Client: NO	GK Metals Corporation		Sheet 2 of 3
Depth Sample (Feet) Numbers	Blow Visual Log Counts Description	Lithologic Description	Notes
60 70 80 100 110 120 130		dark grey dolomite and limestone with shale 75-82' medium to dark grey limestone, trace weathered dark brown shale 82-85' brecciated limestone, quartzite, shale 85-140' medium to dark grey limestone, calcite present	trace olive grey dolomite,fract- ured, water

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	csburg, PA (71	7) 671-6710	rest	Boring/Well Con	Г
Project					Boring No. MW-15B
Client:	NGK M	etals Corporation			Sheet 3 of 3
Depth (Feet)	Sample Blow Numbers Counts	Visual Log Description	Lit	hologic Description	Notes
140			140-147' 147-162' 162-167' 167-175'	medium to dark grey limestone with dolomite medium to dark grey limestone light to medium grey limestone with light brown slightly weathered dolomite	final estimated flow is <5 gpm

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Dunn Geoscien Mechanicsburg, Pa	•		Te	est B	oring	g/Well Con	struction	1 Log
	FI		<u> </u>	<u>-</u>			Boring No. MW-	-16A
Client: NO	GK Metals Co	rporation					Sheet 1 of 2	
Purpose: M	onitoring Wel	l Installatio	n				Job No. 37-3943	3-5756
Drilling Contract	tor : Eichelbe	erger		D:	riller : F	K. Weigle	Total Depth 75 f	ft.
	J. Painter		pecifica	tions Type	Diameter	Hammer Weight lbs.	Date Started 9/12	2/89
Time Log: Begin	n Finish	Depth C	Casing	steel	12'x 6"	Notes:	Date Finished 9/	12/89
			Bore	rock	6"	1	S.W.L. 52.58 ft.	TOC/GI
		,	Well	open	6"	1	Elevation TOC	Surface
		Sa	mpler				328.74 ft.	327.27 f
<u> </u>	N Vis	ual Log				<u> </u>		
Depth Sample (Feet) Numbers	Blow Des	scription		Litholo	gic De	scription	Notes	S
10)-4' 1-5' 5-7' 7-25'	brok calc med lime grey inter oliv	ten lime ite fille ite fil	topsoil wn clay estonewith d veins rk grey vith medium re grey dolomite, t thin beds of n to grey shale dark grey dark grey	no visus	al signs of addition

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Dunn Geose	cience Cor	poration	Test Boring/Well Co	nstruction
Mechanicsburg	g, PA (717)	671-6710	1 cst botting/ wen co	asu ucuvii
Project :	RFI			Boring No. MW-16A
Client:	NGK Met	als Corporation		Sheet 2 of 2
Depth Samp (Feet) Number		Visual Log Description	Lithologic Description	Notes
60 			60-75' medium to dark grey limestone	final estimated flow is <2 gpm

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		e Corpora (717) 671-67		Te	est B	oring	g/Well Co	ns	struction	Log
Project :	RFI	[Boring No. MW-	16B
Client:	NGK	Metals Co	orporation					\neg	Sheet 1 of 3	
Purpose	: Mon	itoring We	ll Installatio	n					Job No. 3943-5-	5756
Drilling (Contracto	r: Eichelb	•			riller : \	Weigle/Knaub		Total Depth 200	ft.
Geologis	st : J. J.	Painter		Specifica	itions Type	Di ame ter	Hammer Weight:	ibs.	Date Started 9/19)/89
Time Log:	Begin	Finish	Depth	Casing	steel	125'x 6"	Notes:	1	Date Finished 11	/2/89
				Bore	rock	6"			S.W.L. 179.55 ft	
				Well	open	6"]	Elevation TOC	ľ
			S	ampler]		327.54 ft.	326.17 ft.
			sual Log scription		Litholo	gic De	scription		Notes	<u> </u>
20				0-4' 4-9' 9-25' 25-26' 26-40'	ol lig lir fra ol lig lir	eathered ght grey ght to m nestone agments ive grey ght to m nestone	y dolomite, nedium grey y dolomite			
60				54-55' 55-60'	lig	ht to da	dolomite, ark grey ,iron stained		red shal	y zones

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		PA (717) FI	671-6710		est Boring/Well Cons	
Projec	· · · · · · · · · · · · · · · · · · ·		tals Corporation	1		Boring No. MW-16B
Client				·		Sheet 2 of 3
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description		Lithologic Description	Notes
60_ _				60-75'	light to dark grey limestone, trace red shaly zones, iron staining	
70					201100, 2011 01.1111111111111	
_				75-123	medium to dark grey limestone, trace clacite	
80						
_						
90						
						96-106' broken
100						zone
 110						
- - 120 						
_				123-12	weathered shale	thin sandstone layer
30—				124-20	00' medium to dark grey limestone, with calcite fragments	estimated water ~ 1 gpm
-						
140						

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Mechanicsburg,) 671-6710		oring/Well Cor	
	FI GK Mar	tals Corporation			Boring No. MW-16B
Client: N	OK ME				Sheet 3 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Litholo	gic Description	Notes
140			140-200' m lir	edium to dark grey nestone	final estimated flow is <2 gpm

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Dunn Geoscier Mechanicsburg, P	-		Te	est B	oring	g/Well Con	struction Log
	FI						Boring No. MW-17A
	GK Metals Co	rporation					Sheet 1 of 2
Purpose: M	Ionitoring Wel	l Installatio	n				Job No. 37-3943-5756
Drilling Contra	ctor : Eichelbe	erger		D	riller : F	K. Weigle	Total Depth 75 ft.
Geologist: J.	J. Painter	- [Specifica	tions Type	Diameter	Hammer Weight lbs.	Date Started 9/6/89
Time Log: Begi	n Finish	Depth	Casing	steel	20'x 6"	Notes:	Date Finished 9/6/89
			Bore	rock	6"	1	S.W.L. 49.05 ft. <u>TOC/</u> GL
			Well	open	6"	1	Elevation TOC Surface
		s	ampler	_		1	321.16 ft. 319.52 ft.
Depth Sample (Feet) Numbers		sual Log scription		Litholo	gic De	scription	Notes
10			0-11' 11-15' 15-16' 16-60'	1 (dolomit weather medium	ed zone to dark grey e and limestone	11-15': trace olive

Dunn Geoscie Mechanicsburg,		-	Test Boring/Well Con	struction
	.FI			Boring No. MW-17A
	GK Meta	als Corporation		Sheet 2 of 2
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
70			0-75' medium to dark grey dolomite and limestone interbedded	final flow is ~1 gpm

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Dunn Ge Mechanicsb		_		Te	est B	oring	g/Well Con	struction	Log	
Project :	R F	_						Boring No. MW-	Boring No. MW-17B	
Client:	NG	K Metals	S Corporation	 l		_		Sheet 1 of 3		
Purpose:	Mor	nitoring	Well Installa	tion				Job No. 37-3943	-5756	
Drilling C					D	riller :	K. Weigle	Total Depth 200	ft.	
Geologist		Painter		Specifica		Diameter	Hammer Weight: 1bs.	Date Started 9/6/	89	
Time Log:	Begin	Finis	sh Depth	Casing	steel	125'x 6"	Notes:	Date Finished 9/	18/89	
		T -		Bore	rock	6"	1	S.W.L. 48.90 ft.	TOC/GL	
				Well	open	6"	1	Elevation TOC	Surface	
				Sampler			1	319.39 ft.	317.62 ft	
- 1		Blow	Visual Log Description		Lithol	ogic De	scription	Notes	<u> </u>	
10			HEHELEKHYKYKYKYKYKYKYKYKYKYKYKYKYKYKYKYKYKYKY	22-23' 23-29' 29-31' 31-34' 34-46'	t d	lark gre medium lolomite proken z ppen lolomite prown sl calcite, l nterbed	y shale to dark grey cone with clay e, occassional haly cuttings and imestone	& sands 31': rod lost circ	uttings trace ey shale stone dropped,	
60				58-60'	v	veathere	ed shale	dark gre brown,t quartzite limonite	race e,	

Dunn Geoscience Co Mechanicsburg, PA (717)	-	Test	Boring/Well Con	struction
Project: RFI				Boring No. MW-17B
	als corporation			Sheet 2 of 3
Depth Sample Blow (Feet) Numbers Counts	Visual Log Description	Lith	nologic Description	Notes
60 70 80 90 110 120 130		60-102' 102-112' 112-140'	medium to dark grey limestone, calcite veins medium to dark grey dolomite and limestone, interbedded, trace brown shale, calcite veins medium to dark grey limestone with calcite fragments	68-93':used very little foam to help lift cuttings, return was sporadic, consumed by void @ 31-34 ft. softer, cuttings were larger, little water return

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Dunn Geoscience Corporation Test Boring/Well Construction Mechanicsburg, PA (717) 671-6710 RFI Project: Boring No. MW-17B NGK Metals corporation Client: Sheet 3 of 3 Depth (Feet) Visual Log Sample Blow Lithologic Description Notes Description Numbers Counts 140 140-200' dark grey limestone with calcite fragments final estimated flow is <2 gpm 150 _ 160 170. 180 190 200

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Test Boring/Well Construction Log 2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (FAX) Boring No. DW-27 Project: NGK Metals RFI Sheet 1 of 2 Client: NGK Metals Corporation Purpose: Corrective Measures Job No. 35525.300 Total Depth 118 Ft. Drilling Contractor: Eichelberger Driller: C. Knaub Specifications Geologist: J. Painter Date Started 6/17/93 Notes: 4"x 020 slot Time Log: Begin Finish Depth Casing Manhole 8" Date Finished 6/23/93 pvc screen 118'-68' Bore 8" S.W.L. 52 Ft. TOC/GL Tubex morie #1 qtz sand and pea gravel 118'-Elevation TOC Surface Well PVC 4" 62.5', bentonite 62.5'-47', bemseal grout 328.20 328.20 Sampler 47'-1.5', Visual Log Depth Blow Sample Lithologic Description Notes Description (Feet) Numbers Counts 0-1.5 macadam, gravel fill Three stainless steel 1.5'-54' brown clay with brown shale, centralizers from 68'-118' Bentonite/cement grout grey limestone, and reddishwhite quartzite fragments 1.5'-surface 10 20 30 50 54'-68' broken grey limestone

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2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (PAX)

			795-8280 (FAX)			Boring No. DW-27
Project : NGK Metals RFI Client : NGK Metals Corp.						Sheet 2 of 2
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description	I	Lithologic Description	Notes
70 — 80 — 100 — 110 — 120 — 130 — 1				68'-72' 72'-83' 83'-85' 85'- 118	77'-78' broken zone	water bearing zone (no estimate) water bearing zone water bearing zone water bearing zone Final flow 10-20 gpm

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2 Market Plaza Way (717) 79. Mechanicsburg, PA 17055 (717) 79.	5-8001 5-8280 (FAX)			عو	5, ,, on oon		208
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Client: NGK Metals Co.	rporation					Sheet 1 of 2	
Purpose : Corrective Me	asures				_	Job No. 35525.30	0
Drilling Contractor : Eic	helberger		Dı	riller : (C. Knaub	Total Depth 120 l	Ft.
Geologist : J. Painter		Specific	ations Type	Diameter	Hammer Weight: lbs.	Date Started 6/23/	93
Time Log: Begin Fin	nish Depth	Casing	Manhole	8"	Notes: 4"x 020 slot	Date Finished 6/29	9/93
		Bore	Tubex	8"	pvc screen 120'-70' morie #1 qtz sand	S.W.L. 50 Ft.	TOC/GL
		Well	PVC	4"	122'-58', bentonite 58'-55", benseal grout	Elevation TOC	Surface
		Sampler			55-1.5'	327.10	327.10
Depth Sample Blow (Feet) Numbers Counts	Visual Log Description		Litholo	gic De	scription	Notes	
10		0-4' 4'-57'	grey shagravel	ale, quar	tzite	Three stainless centralizers fro Cement/bensea 1.5-surface	m 70'-120'

2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (PAX)

			795-8280 (PAX)			
Projec	t: NGK	Metals	RFI			Boring No. DW-28
Client	: NGK	Metals (Corp.			Sheet 2 of 2
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description	L	ithologic Description	Notes
70				63'-74'	grey limestone, broken, occasional clay seam or void	water bearing zone
-				74'-120'	grey limestone	water bearing zone 76'
80 - - -				82'-84'	broken zone	water bearing zone 82' ~ 5 gpm total flow
90—					87'-88' broken zone	water bearing zone
100					99'-100' broken zone	water bearing zone - ~7 gpm
110-					103'-106' broken zone	
120				120'	Bottom of hole	Final flow ~7-10 gpm
				_		

2 Market Pl Mechanics	laza Way ourg, PA 17055	(717) 795-8001 (717) 795-8280 (FA	AX)	-		O	5, 1, 611 6011		208
Project : NGK Metals RFI							Boring No. DW-2	9	
Client: N	GK Metals	s Corpora	tion					Sheet 1 of 2	
Purpose:	Corrective	Measure	s					Job No. 35525.30	0
Drilling (Contractor:	Eichelbe	rger		D	riller :	C. Knaub	Total Depth 120	Ft.
Geologist	: J. Painte	r/T. Seibe	rt	Specific	ations Type	Diame ter	Hammer Weight: lbs.	Date Started 6/29/	93
Time Log:	Begin	Finish	Depth	Casing	Manhole	12"	Notes: 6"x 020 slot	Date Finished 7/6	/93
				Bore	Tubex	8"	pvc screen 120'-60' morie #1 qtz sand	S.W.L. 50 Ft.	TOC/GL
				Well	PVC	6"	121'-54', bentonite 54'-51', benseal grout	Elevation TOC	Surface
			_	Sampler			51'-1.5'	325.61	325.61
	ample Bloumbers Cour	w I Des	ual Log cription		Litholo	gic De	scription	Notes	
10				0-2' 2'-10' 10'-40' 40'-50' 50'-53'	orangisi and sanal shale orangisi light gresseverely ments light gresseverely ments	h-brown dstone fr fragmer h-brown ey and bi y weathe	clay, trace shale	Three stainless centralizers from Bentonite/cem 1.5'-surface	m 60'-120'

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2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (PAX)

Test Boring/Well Construction

Boring No. DW-29 Project: NGK Metals RFI Client: NGK Metals Corp. Sheet 2 of 2 Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 70'-73' light to medium grey limestone 70 with occasional sandstone fragments 73'-76' grey limestone 73'-74' broken zone weathered/broken zone slightly muddy water Total flow <5 gpm 80-76'-82' light to medium grey limestone interbedded with light brown dolomite 82'-89' Major water bearing zone severely weathered limestone, 82' broken zone, muddy water 89'-112' grades to medium to dark grey 90. limestone 100 water bearing zone 110'-110'-112' broken zone 110 112' 112'-120' medium grey to olive grey limestone 120 120' Bottom of hole Final flow >60 gpm 130-

Test Boring/Well Construction Log 2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (FAX) Boring No. DW-30 Project: NGK Metals RFI Client: NGK Metals Corporation Sheet 1 of 2 Purpose: Corrective Measures Job No. 35525.300 Total Depth 121 Ft. Drilling Contractor: Eichelberger Driller: C. Knaub Specifications Geologist: T. Seibert Date Started 7/7/93 Notes: 4" 020 slot Time Log: Finish 8" Date Finished 7/12/93 Begin Depth Casing Steel pvc screen 120'-60' Bore 8' S.W.L. 50 Ft. TOC/GL Tubex morie #1 qtz sand 121'-54', bentonite Elevation TOC Surface Well **PVC** 4" 54'-45', benseal 45'-1.5' 326.51 325.57 Sampler Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 0-2' soil Three stainless steel 2'-7' centralizers from 60'-120' slag, glass and soil Bentonite/cement grout 1.5' to surface 7'-34' orangish-brown silty and sandy soil 10 20 30 34'-48' Buff to grey limestone and dolomite with greenish phyllite beds, broken 40 48'-52' Same as 34'-48', competent 50 52'-64' low water yield Dark grey to blueish limestone with occasional tan to greenish beds, grades to light grey

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2 Market Plaza Way Mechanicsburg, PA 170	(717) 795-8001 055 (717) 795-8280 (PAX)	. 010.	1	cst bornig/ vven e	
Project : NGK I					Boring No. DW-30
Client: NGK M	Metals Corp.				Sheet 2 of 2
	Blow Visual I Counts Descrip		L	ithologic Description	Notes
(Feet) Numbers (1)	Counts Descrip		64'-82' 82'-86'	light grey, brownish-grey to grey limestone and dolomite 64'-71" weathered zone light tan dolomite grades to light grey, brownish-grey to grey limestone and dolomite 93' weathered Bottom of hole	water bearing zone 93' water bearing zone 105' water bearing zone 112' Final flow ~10 gpm

Test Boring/Well Construction Log 2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (FAX) Boring No. DW-31 Project: NGK Metals RFI Client: NGK Metals Corporation Sheet 1 of 3 Purpose: Corrective Measures Job No. 35525.300 Driller: C. Knaub Total Depth 153 Ft. Drilling Contractor: Eichelberger Specifications Geologist: J. Painter Date Started 7/13/93 Notes: Shale trap at Date Finished 7/15/93 Time Log: Begin Finish Depth Casing 18'x6" Steel end of 6' steel casing Bore S.W.L. 50 Ft. TOC/GL 8' rotary (16'), cement/bentonite grout 16'-0 Elevation TOC Surface Well 8" open 331.30 328.89 Sampler Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 0-3' overburden fill, gravel 3'-153' grey limestone 10 • 20 23'-25' fracture zone 30 40 45'-46' broken zone 50 54'-55' broken zone

2 Market Plaza Way Mechanicsburg, PA	17055 (717) 7	STRUCTURE 95-8001 95-8280 (FAX)	Test bornig/wen	Jonsti action
Project : NGI				Boring No. DW-31
Client: NGK	_			Sheet 2 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
_				
1 4				
70				
1 -				
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80—				
-				
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90				
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1 4				
100				
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1 -1			•	
1 -1				
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110				
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120				
120-				
130				
130 _				

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ENVIRONMENT &

2 Mark Mecha	tet Plaza Way nicsburg, PA	INFRA 7055 (717)	STRUCTURE 795-8001 795-8280 (FAX)	Test Boring/Well	Construction
	t: NGK				Boring No. DW-31
Client	: NGK	Metals (Corp.		Sheet 3 of 3
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
(Feet)	Numbers	Counts	Description	153' Bottom of hole	Final flow <2 gpm
_	-		-		

Test Boring/Well Construction Log 2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (FAX) Boring No. DW-32 Project: NGK Metals RFI Sheet 1 of 3 Client: NGK Metals Corporation Purpose: Corrective Measures Job No. 35525.300 Total Depth 150 Ft. Drilling Contractor: Eichelberger Driller: J. Books Specifications Type Hammer Weight: Geologist: J. Painter & G. Buterbaugh Date Started 2/21/94 Diame ter Time Log: Finish Steel 8" & 10" Date Finished 2/7/94 Begin Depth Casing Bore S.W.L. 36.62 Ft. TOC/GL 8' rotary Elevation TOC Surface Well 8" open 319.49 316.79 Sampler Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 0-1', overburden fill, limestone gravel Ten-inch bore hole to 62 1'-36', LOAM, orange-brown with quartzite feet, then 7 7/8-inch bore gravel hole to 150 feet. 10-inch diameter steel casing set to 42 feet, 8-inch 10 diameter steel casing with drive shoe set to 59 feet. 20 10-inch diam, bore hole 30 36'-44', bedrock, broken, weathered with soft muddy zone from 37' to 44'. 44'- 48', DOLOSTONE, medium to dark gray, broken, weathered, intermittent ~Q: 1 - 2 gpm muddy/clay zones, occasional red stained fragment. 50 48' - 117', DOLOSTONE, medium gray, ~ Q: 1 gpm at 63 feet.

competent, occasional iron staining at 110

feet.

2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (PAX)

			795-8280 (PAX)		Desire No. DW 22
	t: NGK	Boring No. DW-32			
Client	: NGK	Sheet 2 of 3			
Depth (Feet)	Sample	Blow Counts	Visual Log Description	Lithologic Description	Notes
(reet)	Numbers	Counts	ļ., <u>.</u>		
_			10-inch	48' - 117', DOLOSTONE, medium gray,	
				competent, occasional iron staining at 110 feet.	
_				ieet.	
	J				
70—				1	
70					
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_				1	
80-				·	
- 00					
_				·	
90—					
_					
				·	
			8-inch diam. bore hole		
100					
_					
_					
110					
_					
120				121' 122' DOLOSTONE di d	
				121' - 123', DOLOSTONE, medium to dark gray, noticeable quartz content increase.	
				123' - 138, DOLOSTONE, medium gray,	
				micro - very finely crystalline, occasional	
_				calcite filled fracture with limonite staning.	
130					
				1201 1421 on observe with a service of 51 11	
				138' - 143', as above with occasional friable brown silt to very fine grained quartz sand.	noticeable increase in Q.
				orown sit to very fine granieu quartz sailu.	

2 Market Plaza Way (717) 795-8001 Mechanicsburg, PA 17055 (717) 795-8280 (PAX)									
	t: NGK	Boring No. DW-32							
Client	Client: NGK Metals Corp. Sheet 3 of 3								
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes				
150 —				143' - 150', DOLOSTONE, medium gray, micro- to very finely crystalline, occasional white calcite filled fracture.150',Bottom of hole, TD.	Final flow (Q)10 to 12 gpm				
160									
170 —									
180									
190 —									
200 —			,						
210 —									

2 Market Plaza Way Mechanicsburg, PA	(717) 795-8001 17055 (717) 795-8280 (F	'AX)	·					
Project : NGK		<u> </u>					Boring No. DW-33	
Client : NGK	Sheet 1 of 2							
Purpose : Corr	Job No. 35525.300							
Drilling Contra	actor: Eichelbe	erger		D	riller : I	K. Weigle	Total Depth 130 Ft.	
Geologist : T.	Date Started 3/9/94							
Time Log: Beg	gin Finish	Depth	Casing	Steel	5'x8"	Notes:	Date Finished 3/15	/94
			Bore	rotary	8'		S.W.L. 37.3 Ft.	TOC/GL
	- -		Well	PVC	4"	1	Elevation TOC	Surface
			Sampler				321.33	319.63
Depth (Fect) Numbers	Blow De	sual Log scription	0-3' 3'-82'	overbur and gra	den fill,	orange-brown soil	Ten-inch bore ho feet, then 7 7/8-in hole to 130 feet. Well Materials: 4" PVC 020-slot 58'-128' 4" PVC riser +1 Morie #1 quartz 58'-130' 00 quartz sand 56 Bentonite pellets Bentonite/grout manual services.	screen 5'-58' sand 5'-58' 54'-56'
30							54'-surface	

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Test Boring/Well Construction

2 Market Plaza Way Mechanicsburg, PA 17	7055 (717) 7	795-8001 795-8280 (PAX)		
Project: NGK	Metals	RFI		Boring No. DW-33
Client: NGK	Metals (Corp.		Sheet 2 of 2
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
60			82' - 84' boulder 84'-98' clayey soil as above with trace amounts of rock fragments 98'-123' Dolostone - light buff to tan with seams of limonite up to 0.5" thick, occasional calcite seams and black dolostone, broken and weathered, becomes more competent around 116' 123'-130'clay and soft dolostone filled void 128' Bottom of well 130' Bottom of borehole	10-inch borehole to 119 ft. 8-inch borehole 119-130 ft.

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Dunn Geoscience Corporation Test Boring/Well Construction Log 2 Market Plaza Way, Mechanicsburg, PA 17055 (717) 795-8001 Boring No. MW-18 Project: NGK Metals RFI Sheet 1 of 1 Client: NGK Metals Corporation Purpose: Phase II RFI Job No. 5756 Drilling Contractor: Eichelberger Total Depth 55.5' Driller: E. Funk Specifications Hammer Weight: Geologist: J. Painter Date Started 6/5/91 Diamete Notes: 6" 020 slot Time Log: Finish Depth Casing 10" Date Finished 6/7/91 Begin Steel pvc screen 55.5'-35.5' Core morie #1 qtz sand S.W.L. 29.89 TOC/GL 55.5'-31', bentonite Elevation TOC Surface PVC 6" Well 31'-5', 10" steel well 332.33 guard with locking Sampler Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 0-0.5' soil cover 0.5'-13' red mud 10 13'-17' c. gravel (qtzite), trace limestone gravel, wood pieces, glass, copper shavings 17'-20' very coarse gravel, boulders hard drilling 20'- 24' gravel with sand, clay 20 24'-35' clay, sand and coarse gravel 30 brown clay, sand and trace gravel 49'-54' severely weathered brown shale with dark grey limestone laminae 54'-55.5' competent medium grey limestone final flow ~15-25 gpm 55.5' bottom of hole

Dunn Geoscieno 2 Market Plaza Way, M (717) 795-8001	ce Corporation Mechanicsburg, PA 17055	Test	t Boring	g/Well Con	struction	Log
						19
Client : NGK Me	tals Corporation				Sheet 1 of 2	
Purpose : Phase I	I RFI				Job No. 5756	
Drilling Contracto	or: Eichelberger		Driller : I	E. Funk	Total Depth 65'	
Geologist : J. Pair	nter	Specification	ns Type Diameter	Hammer Weight Ibs.	Date Started 6/7/9	1
Time Log: Begin	Finish Depth	Casing S	teel 10"	Notes: 6" 020 slot	Date Finished 6/1	1/91
		Core		pvc screen 65'-35', morie #1 qtz sand	S.W.L. 30.00	TOC/GL
		Well P	VC 6"	65'-30.5', bentonite 30.5'-5', 10" steel	Elevation TOC	Surface
		Sampler		well guard with locking cap	334.11	
Depth Sample	Blow Visual Log	7.	thalasia Da			
	Description Description	1.1	thologic Des	scription	Notes	
10		0.5'-5' r. 5-17' c. 17'-25' v. 20'- 24' g.	oil cover red mud gravel (qtzite) gravel with san gravel and gravel and	vel, boulders d, clay d clay		

Project : NGK	Boring No. MW-19				
Client : NGK M					
					
(Feet) Numbers	Counts Description	Lithologic Description	Notes		
Depth (Feet) Numbers		Lithologic Description 60'-65' weathered brown shale, dark grey limestone 65' bottom of hole	final flow ~50-60 gpm		
<u> </u>					
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(717) 795-8001 Project : NGK Metals RFI								Boring No. MW-2	0
		ls Corpora	tion				-	Sheet 1 of 1	
	Phase II I						_	Job No. 5756	
		: Eichelbei	raar			rillor · I	E. Funk	Total Depth 52'	
<u> </u>	: J. Paint		igei	Specifical	ions	_	Hammer	Date Started 6/11/	01
Time Log:	Begin	Finish	Depth	Casing	Type Steel	Diameter	Notes: 6" 020 slot	Date Finished 6/13	
Time Log.	Tog	T		Core		10	pvc screen 52'-32' morie #1 qtz sand	S.W.L. 32'	TOC/GI
				Well	PVC	6"	52'-29', bentonite	Elevation TOC	Surface
				Sampler	PVC	0	29'-5', 10" steel well guard with locking	334.56	
	<u> </u>		17	Sampler	_	_	сар		
	- I		sual Log scription		Litholo	gic De	scription	Notes	
10				0-1' 1'-5' 5'-11' 11'-20' 20'- 29' 47'-52' 52'	refracting gravel fine to and sa gravel sand a	id, metal tory fill, som coarse g nd , sand an mto darl	lic debris, slag and the green staining travel, boulders d boulders I		
_								final flow ~:	30 gpm

Dunn Geoscience 2 Market Plaza Way, Mec (717) 795-8001		Test	t Boring	g/Well Con	struction Log
Project : NGK Metals RFI					Boring No. MW-21
Client : NGK Metal	s Corporation				Sheet 1 of 1
Purpose: Phase II R	RFI				Job No. 5756
Drilling Contractor:	Boyles		Driller : A	Anderson	Total Depth 60'
Geologist : J. Painte	r/ B. Heine	Specification	IS Type Diameter	Hammer Weight lbs.	Date Started 3/19/91
Time Log: Begin	Finish Depth	Casing St	teel 6"	Notes: 2" 010 slot pvc screen 60'-25'	Date Finished 3/25/91
		Соте		morie #1 qtz sand	S.W.L. 24.10' <u>TOC</u> /GL
		Well P	VC 2"	60'-20', bentonite 20'-10', 6" steel well	Elevation TOC Surface
		Sampler		guard with locking	331.99 329.79
Depth Sample Blo	Visual Log	т ;,	thologic Dec	·	Natas
(Feet) Numbers Cour	I Description	Lit	thologic Des	scription	Notes
10		3.5'-10' m w 10'-26' li 26'-30' v 30'-31' cl	ight to medium	n, calcite veins	

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Dunn Geoscience Corporation Test Boring/Well Construction Log 2 Market Plaza Way, Mechanicsburg, PA 17055 (717) 795-8001 Boring No. MW-22 Project: NGK Metals RFI Client: NGK Metals Corporation Sheet 1 of 2 Purpose: Phase II RFI Job No. 5756 Total Depth 72' Driller: Robbins/Kelly Drilling Contractor: Boyles Specifications Hammer Weight Geologist: J. Painter Date Started 3/14/91 Турс Notes: 4" 010 slot Finish 8" Date Finished 3/19/91 Time Log: Begin Depth Casing Steel pvc screen 72'-32' Core S.W.L. 27' TOC/GL morie #1 qtz sand 72'-27.5', bentonite Elevation TOC Surface PVC 4" Well 27.5'-25', 8" steel 330.39 328.19 well guard with Sampler locking cap Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 0-1.5' overburden gravel fill 1.5'-2' cinder fill 4' dark grey limestone 2'-12' light brown clay fragments 10 12'-14' void 14'- 57.5' brown clay, severely weathered shale 20 30 40

Project : NGK N	Boring No. MW-22 Sheet 2 of 2		
Client : NGK M	 		Sheet 2 of 2
Depth Sample (Feet) Numbers	sual Log scription	Lithologic Description	Notes
70		57.5'-72" dark grey limestone, red shale, occasional quartz fragment	
		72' bottom of hole	final flow ~4 gpm
80			
90 -			
00-			
10		,	
20—		,	
30			

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Project : NGK Metals RFI							Boring No. MW-23	
Client : NGK Metals Corporation							Sheet 1 of 2	
Purpose : Phase	II RFI						Job No. 5756	
Drilling Contra	ctor: Boyles			. D	riller : A	Anderson	Total Depth 73'	
Geologist : B. I			Specifica	ations Type	Diameter	Hammer Weight: lbs.	Date Started 3/19/	91
Time Log: Beg	n Finish	Depth	Casing	Manhole	8"	Notes: 4" 010 slot pvc screen 73'-43'	Date Finished 3/20	6/91
			Core			morie #1 qtz sand	S.W.L. 34.10'	TOC/GI
		-	Well	PVC	4"	73'-38', bentonite 38'-10', flush mount	Elevation TOC	Surface
			Sampler			manhole well guard with locking cap	327.27	327.27
Depth Sample		sual Log		T :41 - 1 -			\	
(Feet) Numbers	Counts De	scription		Lithoic	igic De	scription	Notes	
10 — 10 — 20 — 30 — 40 — 50 —			2'-2.5' 2.5'-3' 3'-4' 4'-7' 7'-8.5' 8.5'-29	ments coarse red cla light to light ye clay as (1-3mr	gravel st y medium ellow bro	ained red to brown clay own clay own clay shale, soft		

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Project : NGK	Boring No. MW-23			
Client : NGK		Sheet 2 of 2		
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
70			62'-69' dark grey limestone, weathered, fractured 69'-74' dark grey limestone, trace calcite veins, trace red staining, fractured red and gray shale chips 74' bottom of hole	final flow ~5 gpm

(717) 795-8001 Project : NGK Metals RFI							Boring No. MW-24				
	NGK M			ation						Sheet 1 of 2	
Purpose			<u> </u>			-				Job No. 5756	
Drilling			_	rger			Di	riller : 1	Brooks	Total Depth 63'	
Geologi						Specifica	itions Type	Diameter	Hammer Weight lbs.	Date Started 4/1/9	1
Time Log:			Finish	Dep	th	Casing	Manhole	8"	Notes: 4" 020 slot	Date Finished 4/3	/91
	T -					Core		_	pvc screen 63'-33' morie #1 qtz sand	S.W.L. 32'	TOC/GI
						Well	PVC	4"	63'-30', bentonite 30'-2', flush mount	Elevation TOC	Surface
						Sampler			manhole well guard with locking cap	298.82	298.82
Depth	Sample	Blow		sual Log			T jehala	gio Do		NT	
	Numbers	Counts	T P	scription	-		Linioro	gic De	scription	Notes	
10 -	-						boulded fracture buff to with dorange ments, white 5' fracture 7' quartz	tan dolo ark grey e mud wi , sand, b dolomite red rock	omite, interbedded limestone, brown- ith quartzite frag- reccia fragments,		
30	- - - - - - - - - - - - - - - - - - -						clay s 5' bould 7' clay	eam, voi			

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Dunn Geoscience Corporation Test Boring/Well Construction 2 Market Plaza Way, Mechanicsburg, PA 17055 (717) 795-8001 Boring No. MW-24 Project: NGK Metals RFI Client: NGK Metals Corporation Sheet 2 of 2 Visual Log Depth Sample Blow Lithologic Description Notes Description (Feet) Numbers Counts 57'-63' grey limestone 63' bottom of hole final flow ~5 gpm 100-120-130

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(717) 795-8001 Project : NGK Metals RFI							Boring No. MW-25	
Client : NGK M		tion					Sheet 1 of 3	
Purpose : Phase							Job No. 5756	
Drilling Contract		others			riller : (Guiseppe	Total Depth 178'	
Geologist : J. Pa			Specifica		Diameter	Hammer Weight lbs.	Date Started 8/22/	91
Time Log: Begin		Depth	Casing	steel	6"x72'	Notes: 6" steel casing	Date Finished 8/22	2/91
			Core			with drive shoe tremie grouted with	S.W.L. 72'	TOC/GI
			Well	open	6"	locking cap	Elevation TOC	Surface
		_	Sampler		L	1	327.26	325.46
	Pi Vis	ual Log						
Depth Sample (Feet) Numbers		scription		Litholo	gic De	scription	Notes	
20			0-0.5' 0.5'-12' 12'-37'	orang hered ments	ish-brow shale an	ravel (rounded), sand on clay with weat- d dolomite frag- ale interbedded with shaly dolomite, soft	wet @ 10'	

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Projec	t : NGK	Metals	RFI			Boring No. MW-25
		_	Corporation			Sheet 2 of 3
Depth (Feet)	Sample Numbers	Blow Counts	Visual Log Description	Lit	thologic Description	Notes
			2 2 2 2 2 2			
				63'-71'	light brown shale interbedded with grey dolomite	
70 				71'-82'	competent rock as above grades	
					to light brownish-grey to grey dolomite	
80-						
				82'-148'	buff to light grey dolomite, oc- casional reddish brown sandy horizon, trace iron staining	
_					nonzon, uace non stanning	
90 —						
_						
100-						
_						
110						
_						
120—						
- -						
_						
130 -						
_						
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Dunn Geoscience Corporation 2 Market Plaza Way, Mechanicsburg, PA 17055 (717) 795-8001			Test Boring/Well Co	
Project : NGI	Metals	RFI		Boring No. MW-25
Client : NGK	Metals C	Corporation		Sheet 3 of 3
Depth Sample (Feet) Number	Blow Counts	Visual Log Description	Lithologic Description	Notes
150 — - - - - 160 — - - - 170 —			148'-178' iron stained, weathered shale and dolomite, trace quartzite	148' flow increases
180 —			178' bottom of hole	final flow ~ 15 gpm
210 —				

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	oscience aza Way, Mec 001			Те	est B	oring	g/Well Con	struction	Log
Project : NGK Metals RFI								Boring No. MW-	26
Client : N	GK Metal	s Corpora	tion					Sheet 1 of 3	
Purpose:	Phase II R	FI						Job No. 5756	
Drilling C	Contractor:	Myers B	rothers	1	D	riller : (Guiseppe	Total Depth 202	
Geologist	: J. Painte	r		Specifica	tions Type	Diameter	Hammer Weight lbs.	Date Started 8/22	/91
Time Log:	Begin	Finish	Depth	Casing	steel	6"x42'	Notes: 6" steel casing with drive shoe	Date Finished8/2	6/91
				Core			tremie grouted with	S.W.L. 39'	TOC/GL
				Well	open	6"	locking cap	Elevation TOC	
			_	Sampler				284.48	283.28
	ample Blo	w Des	ual Log scription			ogic De	scription	Notes	3
10 — 10 — 20 — 30 — 40 — 50 —				0-1' 1'-18' 18'-22' 22'-39'	orangi: brown shaly o	carbonate	erely weathered rock, iron stained	water @ 15 to 4' little water	r observed

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Dunn Geoscience Corporation 2 Market Plaza Way, Mechanicsburg, PA 17055 (717) 795-8001			Test Boring/Well C	onstruction
Project : NGK	Metals	RFI		Boring No. MW-26
Client : NGK	Metals C	Corporation		Sheet 2 of 3
Depth Sample (Feet) Numbers	Blow Counts	Visual Log Description	Lithologic Description	Notes
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(717) 795-8001 Project : NGK Metals RFI						Boring No. MW-26
	GK Metals		n			Sheet 3 of 3
Depth S	mple Blow mbers Counts	Visual I	.og	Lit	hologic Description	Notes
150-150-150-170-170-170-170-170-170-170-170-170-17				202'	light to medium grey limestone	final flow ~3 gpm

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Dunn Ge 2 Market Pla (717) 795-80	eoscience (aza Way, Mech 001	Corporat hanicsburg, I	ion PA 17055	Te	est B	oring	g/Well Con	struction	Log
Project : 1	NGK Meta	ls RFI						Boring No. P-1	
_ -	IGK Metals		ition					Sheet 1 of 1	
Purpose:	Phase II R	FI						Job No. 5756	
Drilling (Contractor:	Boyles			D	riller :K	Celly	Total Depth 45'	
Geologist	t : J. Painte	r		Specifica	itions Type	Diameter	Hammer Weight lbs.	Date Started 3/19	/91
Time Log:	Begin	Finish	Depth	Casing	Steel	4"	Notes: 2" 010 slot pvc screen 45'-30'	Date Finished 3/2	21/91
				Core			morie #1 qtz sand	S.W.L. 32'	TOC/GL
				Well	PVC	2"	45'-28', bentonite 28'-27', 4" steel well	Elevation TOC	
				Sampler			guard with locking	302.35	300.55
	Sample Blow umbers Coun	w Des	sual Log scription		Litholo	gic Des	scription	Notes	
10				21.5'-2 24'- 28 28'-28.	light b pebble boulde brown brown gravel 5 light b 4' gravel ' light b 5' gravel 2' light b	ite gravel prown silt es ers a silty san a silt, sand -subangu prown san prown cla	ılar, brown silt	final flow	√~5 gpm